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THE WALNUT LANE CONCRETE ARCH BRIDGE ACROSS THE WISSAHICKON, PHILADELPHIA.

It has been the policy of the Engineering Department of the City of Philadelphia to provide the city with bridges which satisfy the aesthetic eye as well as to conform with engineering and economic practice. Particularly has this been so in Fairmount Park. One of the latest of their bridges, begun last summer and now in process of construction, is the Walnut Lane Bridge, which crosses the Wissahickon Creek on the line of Walnut Lane and will be the connecting link between the suburbs of Germantown and Roxborough. The Wissahickon at this point, some 90 ft. in width, runs through a heavily wooded gorge whose banks slope steeply back to an elevation some 140 ft. higher than the creek level. The surroundings are the typically wild and picturesque country of the outlying portions of Fairmount Park, and call for a design in harmony.

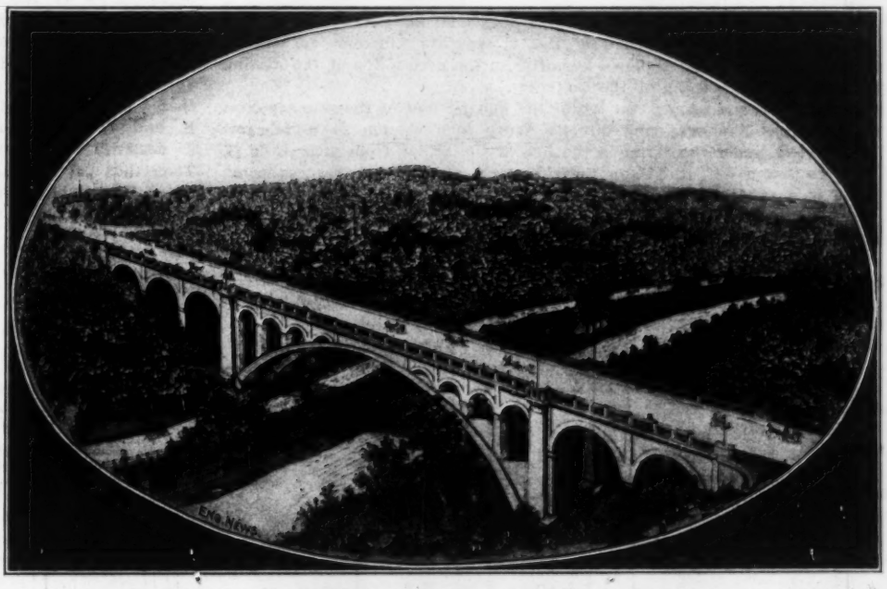

FIG. 1. THE WALNUT LANE BRIDGE NOW UNDER CONSTRUCTION ACROSS WISSAHICKON CREEK, FAIRMOUNT PARK, PHILADELPHIA, PA. VIEW FROM A PERSPECTIVE SKETCH.
Span 232 Ft.; Rise 147 Ft. Above Water.
Geo. S. Webster, Chief Engineer; Henry H. Quimby, Assistant Engineer; Reilly & Riddle, Contractors.

GENERAL DESCRIPTION.

The bridge is 585 ft. over all and consists of a main arch of 233 ft. between abutments, approached on one side by two and on the other by three arches of 53 ft. span. The roadway is 40 ft. wide with two 10-ft. sidewalks. The whole structure is built throughout of concrete, and except in some walls and columns hereafter mentioned is not reinforced. It is designed to carry highway traffic.

MAIN ARCH.—Fig. 2) The main arch, which is a three-centered curve 232 ft. span, at springing line, 70 ft. 3 in. rise, is made up of twin arch rings each 21 ft. 6 ins. wide and 9 ft. 6 ins. thick at the haunch, and 18 ft. wide and 5 ft. 6 ins. thick at the crown. These twin arches spring from abutments 25 ft. 6 ins. wide founded some 12 ft. below the surface on stepped footings reaching to solid rock. The main piers or main arch abutments are solid for the width of the bridge to a point immediately above the springing line of the arches, above which point they divide into two parts each of the same width as the arch rings, and joined together at the top by a small counter arch.

The abutments are reinforced near the bottom by one plane of 1-in. sq. rods parallel to the springing face of the arch and running transverse to the line of the bridge.

From each arch ring rise T-shaped cross walls of concrete which act as supporting piers for the spandrel arches. There are in the line of the bridge two of these pillars and accompanying arches to each arch ring, making four lines of spandrel arches. The pillars nearest the abutments are bonded with the arch ring by 1-in. sq. rods. The arch ring is reinforced under each pillar by three 1-in. sq. rods running transverse to the line of the arch.

The floor system (see Fig. 4) is carried on I-beams, 15 in.-42 lb. beams on the outside and 20 in.-65 lb. beams in the middle, which span across the spandrel walls. These I-beams are tied together, as shown in the drawing, by ⅞-in. tie rods and the floor system is carried between them by jack arches. Over the spandrel walls and main piers the 15-in. I-beams are omitted and 1-in. sq. rods are substituted as reinforcement.

The roadway is made up of a cinder fill on top of the embedded I-beams mentioned above, topped off with a 6-in. layer of concrete and a final 3½-in. layer of asphalt. The sidewalk is of concrete reinforced by 1-in. sq. rods.

The railing is of concrete with the pedestals and pilasters cast in place and the balusters molded separately and set afterward. All copings, molds and cornices that project from the main face of wall are reinforced with small rods bonding back into the wall.

Expansion is provided for by making each floor system between spandrel pillars fixed to one end pillar and movable on the top of the other. (See Fig. 4.)

SMALL ARCHES.—The small approach arches are 53 ft. in span and 1 ft. 6 ins. arch thickness, with an exposed arch face 2 ft. 3 ins. deep. All the details of columns and floor beams are the same as in the large arch, except that there are no spandrel arches, the outside face being carried to the floor level by a solid wall.

MATERIAL AND FINISH.

The material used in the construction might be called a rubble concrete. In all foundations, stones of derrick size may be embedded, and smaller stones may be embedded with them, but not closer than 2 in. to any face. The concrete now being placed in the abutments to the main arch and to be used in the rest of the work, except the arch rings, consists of a 1:3:6 mixture, the crushed stone varying from ¾-in. to 1½ in. in size. This is supplemented by the use of stone varying in size from 12 in. largest diameter to some stones of derrick size. These stones, which are rough and sharp as they come from the quarry, are deposited in each layer of the concrete when it is in a plastic state and rammed down to about their mid-depth, thus leaving a bonding line of stones sticking up from each finished layer. The main requirement of the engineer is that these bonding stones shall be deposited in a soft concrete so that they have opportunity to get the full benefit of the setting process. In the abutments to the main arch the embedded stones are of flat shape and an effort is made to place them in a plane normal to the direction of the resultant thrust of the arch.

It is intended to extend this large stone process to the arch rings, it being specified there, however, that a 1:2:5 mixture be used and that the embedded stone shall be not less than one-man size and of such shape that their thickness will be approximately one-quarter of the average dimension. They are to be laid radially in a way resembling the voussoirs of a masonry arch. At the points covered by the spandrel piers and walls a number of these stones will project abev the arch ring to act as dowels.

The finish of the surface is the wash face described in this journal of Dec. 20, 1906, in a "Surface Finish for Concrete," by Mr. Henry H. Quimby. The finish is illustrated in Fig. 1 of that article. The aggregate of the granolithic face is made up from a crushed black trap rock.

This rock crushes into small flaky particles about ¼-in. in diameter, with a peculiar dull luster. The effect of the finished washed wall is remarkably like a dark hornblende granite, and gives a face of equally as good an appearance as a bush-hammered surface at a much smaller cost.

CENTERING.—As this is the largest masonry arch ever built in this country and the third largest in the world, the falsework is of particular interest. It was designed in the office of the contractors and approved by the city engineers. The distinctive features of this falsework are its great span and height and the moving of the whole system intact from under one finished arch to the other side of the bridge for use in building the twin arch.

In most large arch falseworks indeterminate stresses usually result from the truss like arrangement of the timbers immediately under the arch ring. The exact line of force that a weight on a sloping surface will take is dependent on the friction between the two bodies, and this friction in concrete varies as the state of the concrete changes from a semi-liquid mass to a solid rock. Add to this the extremely complicated systems of truss sometimes used to carry the load from the lagging through the joists to the main members of the centering and the great difficulty in getting a joint in timbers over 10 × 10 ins. which will carry the maximum strength of the material, and it will be seen that down which vertical the stresses are to be carried to the footings is problematical.

This problem has been partly solved by the designer in this falsework by the use of very heavy joists, spaced quite close together, resting directly upon vertical posts. The heavy 6 × 16 in. joist will carry the stresses to the posts and no cumbersome truss nor loose miter joint prevents the stress from passing directly down the main verticals. The determination of these stresses is not of such importance in fixing the size of members used in the centering, for they are in most cases built with an excessive factor of safety. In an arch of the size of this one, however, the deflection and settlement of the centering is quite large, and upon such deflection the method of laying up the arch ring is to a great extent dependent. It is important, therefore, to know the direction of the stresses in order to determine in just what order the blocks should be laid up to make the deflections in adjoining portions of the arch ring a minimum.

The centering is divided into five parts (see Fig. 5), first, six masonry piers running the whole width of the bridge, upon which the structure is to move; second, a steel framework up to E G, under one arch, 50 ft. wide and called the "primary bent;" third, a separate timber portion below the heavy lines E I and W' I', the purpose of which will appear further on; fourth, the main "staging," 50 ft. wide and included between E I I' W'; fifth, the "upper trestle," 25 ft. wide and extending from I I' to the intrados.

The "primary bent" consists of four I-beam column-bents spaced about 30 ft. apart in the line of bridge and 5 ft. tranversely. The upper and lower chords are made up of channel sections and the whole is cross braced transversely by angle irons.

Each row of columns is carried on temporary concrete piers, sunk into the bed of the creek. These piers, which run the whole width of the bridge, are capped with a 19 × ¾ in. plate, which acts as a bed for the rollers upon which the falsework is moved. The rollers are of hard steel, 6 in. diameter and 1 ft. 6 in. long. The pier "E" acts the same as piers T to W, but pier "G" has a separate function, as will be shown hereafter in the description of the moving of the centering.

On top of the upper chord of the primary bent and directly above each column 24-in. I-beams run in the line of the bridge from piers E to G. Upon these I-beams rests the timber centering, separated from the steel work by some lifting device yet to be decided upon. At the top of the "staging" there is to be a second lifting device.

The timber centering has for its main members 10 × 10 in. yellow pine posts, spaced 5 ft. c. to c. transversely and about 15 ft. c. to c. longitudinally. Every 22 ft. in height these posts are crossed by 10 × 10 in. transverse plates and either 3 × 12 in. or 4 × 12 in. plates, varying in number from 8 to 12, in longitudinal section. The "staging" is 50 ft. in width, but above the second line of moving devices the "upper [illegible]" narrows to 25 ft. in width. On the [illegible] of columns of this upper trestle run 10 [illegible] in. caps and spaced 1 ft. c. to c. on them [illegible] joists curved to the arch ring and va[illegible] size from 6 × 16 in. to 6 × 18 in. The la[illegible] is 1½-in. tongue and groove yellow pine pl[illegible] on one side. The entire timber structure is [illegible]-braced both ways by 3 × 9 in. plank.

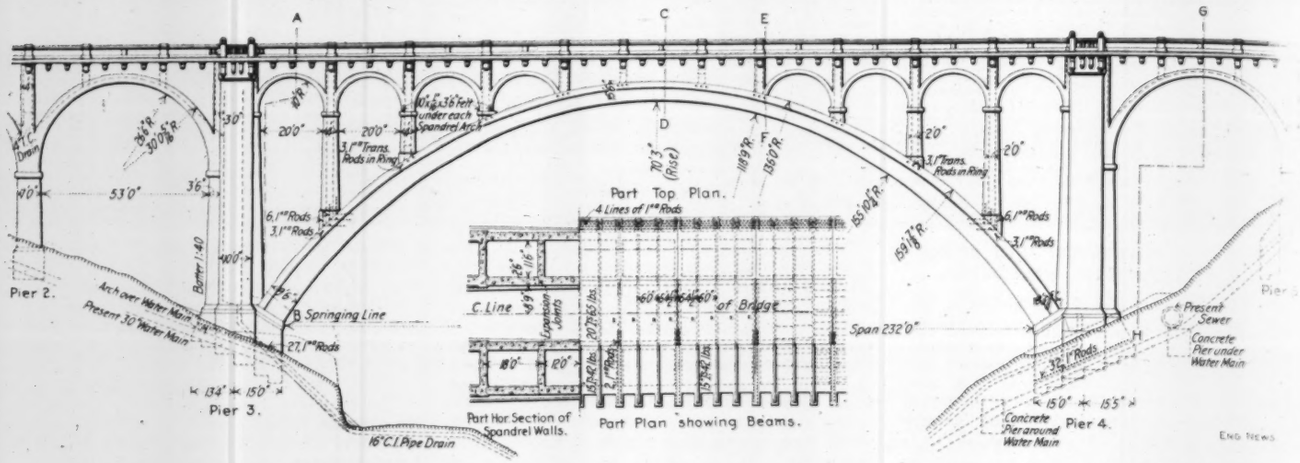

FIG. 2. GENERAL ELEVATION AND PART PLAN OF 232-FT. ARCH AND TWO TYPICAL 53-FT. ARCHES OF THE WALNUT LANE BRIDGE.

The centering will be erected as the one structure shown in the general elevation of Fig. 5, under one twin arch. The steel portion will be bolted down to anchors fixed in the masonry piers and will rest immovable on the rollers. The single arch will be erected up to the spandrel arches. Then the whole center will be struck and the wedges or sand-boxes lowered under that portion of the arch ring between K and I, and K' and I', this having been so designed as to permit a separate lowering. Then that part of the falsework between K O, I and E, and between W, W', I', K' and G will be taken down, and set up again in its corresponding position in the twin arch. No roller is provided at G, and the 24-in. I-beam will be bolted, not riveted, at W' so as to allow for this movement.

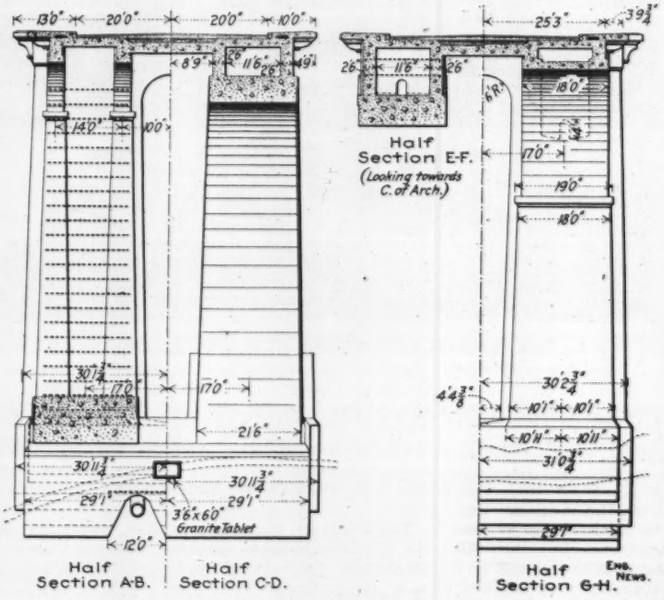

FIG. 3. TRANSVERSE SECTIONS THROUGH WALNUT LANE BRIDGE.

These side sections being erected under the new arch, the steel work will be unbolted from its bed on the masonry piers and the whole structure remaining will be moved bodily on the steel rollers upon the piers to its new position under the twin arch. The center will be then lifted to its proper height and work can proceed under the second part.

GENERAL DETAILS.

The headquarters of the work are on the Roxborough side, where the yards, shops, mixer and offices are located. The work is controlled by an aerial cableway from one high bank to the other with individual stiff-leg derricks at each part of the structure. The bridge was designed under the direction of Mr. George S. Webster, M. Am. Soc. C. E., Chief Engineer of the Bureau of Surveys of the City of Philadelphia, and Mr. Henry H. Quimby, M. Am. Soc. C. E., Assistant Engineer (Bridges). The contractors are Messrs. Reilly & Riddle, and their engineer is Mr. Moris Bernstein. The contract price is $253,551.

RESIDENTIAL SEPTIC TANKS.

By [illegible]TON T. ASHLEY,† M. W. Soc. C. E.

In the [illegible] 1890 I moved to the suburbs of Chicago, into a new residence, having in it all the modern conveniences [illegible]ced there in anticipation of the future introduction of sewers and water service. At the beginning of my eleven years' occupation of these premises I desired to make use of the bath and toilet room, kitchen sink and the like, and immediately conceived the idea of installing a force pump and putting a water tank in the attic, and carried out the project. Immediately near the walls of the residence an improvised cesspool had been put in by the builder of the house from whom I had purchased the property, but its inadequacy to properly care for the household wastes from a family of three was exceedingly apparent. Not being inclined to blindly adopt its use and wait results, I concluded to and did run a small drain from it, which drain emptied out upon the surface of some vacant property near by. Into this catchbasin I conducted the overflow of the storm-water cistern and also equipped the interior of it with a sort of board screen that would prevent the floating solid matter from passing out of the receptacle into this drain. At the end of two years, because of self-condemnation for my negligence, I cleaned out the tank, but afterward chided myself for having gone to the trouble, for I found little to clean out save a few inches of sludge in the bottom. After a lapse of perhaps two years another cleaning was made, with the same results as before. Some years later one of the first articles on the experimental results of Septic Tanks in England appeared in an American technical journal, followed some weeks or months later by other and more explicit articles which revealed the principles of their operation, when it dawned on me that I had constructed a septic tank without knowing it. Later the arrangement was rebuilt to more correctly meet the existing conditions, with a marked improvement in results. The new arrangement was built so as to time more correctly the flow of sewage through the tank, which resulted in an apparent complete decomposition of all the organic solids which entered it. Before passing I desire to note that during my eleven years' residence at this place at no time did I ever see any effluent coming away from the outlet of the drain spoken of, which outlet was less than 150 ft. distant. The earth had absorbed it.

When called on, about the year 1900, to design, lay out and take part in the building of Zion City, Ill., the matter confronted me of providing some means of producing a sanitary condition of things for a people that sprang in numbers from nothing to five thousand in less than one year. On the strength of my own experience, Residential Septic Tanks were prescribed and designed for every house whose owner desired to install therein and use some or all of the modern sanitary conveniences, and as the territory on which this city was built had been originally well-drained farm land, the farm drains were utilized and made to serve as outlets for the many tanks that were built there, and the tanks, unimproved as these original ones were, are to-day still in successful use. This method completely solved the problem of immediate sanitation and that same satisfactory service then inaugurated is quite likely to continue so long as the farm drains remain available.

Although stimulated as I have been by the success of these individual tanks, I still felt that the matter of the final disposal of house sewage on one's own premises was not effected. Seeing the necessity for subsequent aerobic bacterial treatment I set myself to the task of devising some means whereby aerobic processes could be accomplished without the employment of open filter beds that required automatic alternating dosing gears, impossible of operation on level ground, and without the introduction of siphons or the siphon principle. The outcome of this was the invention of an underground nitrification duct, which provides abundantly for the division and ærification of the tank effluents, thereby setting up, as it does, a most active and effectual aerobic nitrifying process, which causes the noxious gases to quickly dissolve and the liquids to complete the purification to a degree ready to be returned to the earth in their original harmless inorganic constituency again to begin another food cycle. This duct is laid on a greater or less thickness of some foraminated inorganic material, such as crushed stone, furnace slag or the like, with provision for the introduction and free continuous circulation of air throughout its entire length. This nitrification duct performs the same part in the purification of the liquid of the tank effluent as do the contact beds or filter beds heretofore spoken of, and acts much in the same way, with the exception that the nitrification duct is much better provided with internal circulation and distribution of fresh air, the purifying effect of which need not be urged upon anyone. The connection of the nitrification duct with the septic tank and indirectly with the soil pipe of the house causes the air to be literally pulled into and through the duct continually, differing in that respect from the contact or filter beds. Contact and filter beds, as has been shown, need their seasons of rest, it being not safe to dose them more often than from one to three times a day, giving them a few hours resting empty between each dosing. Doing this admits of their self-purification, but unlike its prototype, the Ashley Nitrification Duct, needs no automatic mechanical contrivance to control its action, for with the ordinary households of this country little, if any, sewage is produced during the hours of the night, thereby permitting the air to get in its purifying work and to prepare the duct during the night time for the next day's dosing. Then also, even while the duct is in use in the daytime, never for a moment is it so filled as to prevent the free circulation of the air therein and hence these nitrifying processes are greatly facilitated through every hour of the day, whether the duct is being dosed or not. A Compound Nitrification Duct consists of one duct placed a few inches or even feet below another, yet unconnected with it. In this case no air vent is provided for the upper one, with the result that the filtering material which surrounds them is the better supplied with air. A Duplex Nitrification Duct consists of two or more ducts so arranged as to be used alternately, the flow into either one of which is controlled by a simple device thrust into one of the ducts so as to deflect the flow of the tank effluent into the other. The duplex duct is contrived merely as a safeguard to prevent the possible sickening of the soils at the immediate upper end of the duct in case of a prolonged increase of flow of sewage, which increase would also cause a possible decrease in effectiveness.

And now comes the all-important matter of the disposal of the fluids after the processes of the duct have been completed. All there is to say about this is, that it is entirely dependable upon available disposal area into which the duct may penetrate and upon the degree of porosity of the soil to allow of the absorption of the fluids and their distribution throughout the filtering material. At best, this feature of the

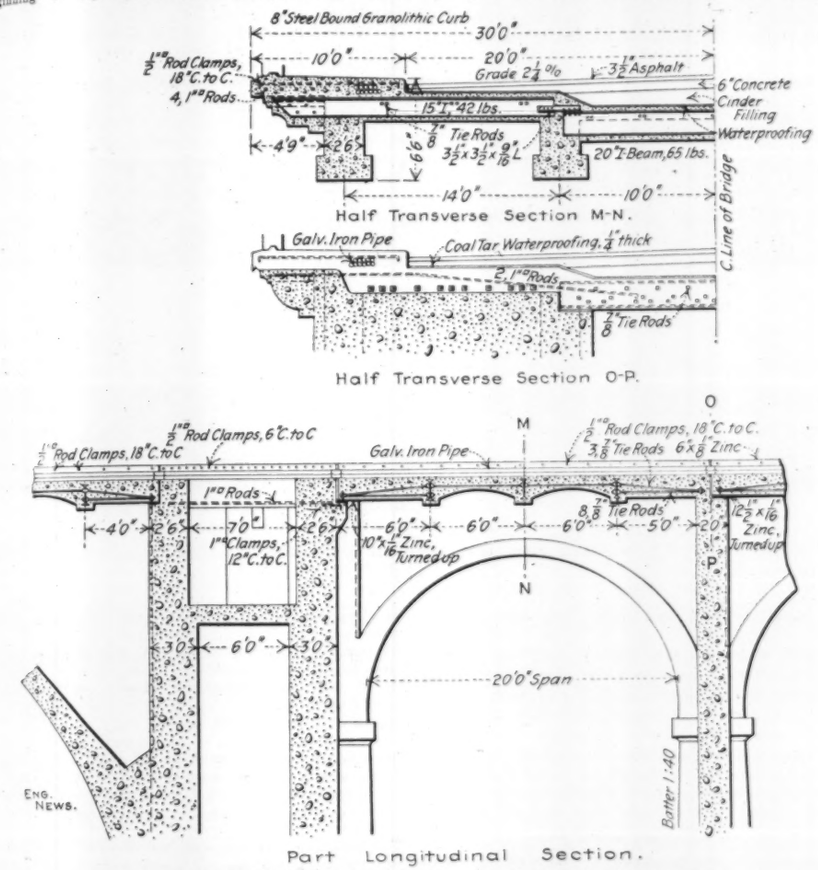

FIG. 4. SECTIONS THROUGH FLOOR OF WALNUT LANE BRIDGE.

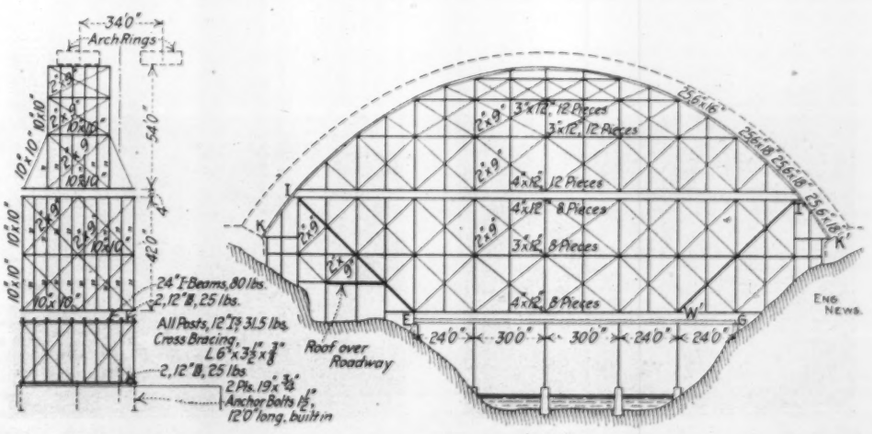

FIG. 5. CENTERING OF MAIN ARCH IN WALNUT LANE BRIDGE.

*From a paper entitled "Sewage Disposal Without Sewers," read before the American Society of Inspectors of Plumbing and Sanitary Engineers, Cleveland, Ohio, January, 1907.

†Chicago, Ill.

installation, so far as location, character and extent is concerned, is always bound to remain a matter of engineering judgment, and no royal road nor hard and fast rule can be laid down independently of either of these three features. Experience alone is necessary in order to correctly design this feature of the disposal arrangement. Every location will present features and conditions entirely peculiar to itself, and the best location as well as the capacity and the character of the duct can only be determined after these conditions are well known by the designing engineer.

For fifteen years I. have given this subject much thought and experimentation, and is it not pertinent that I demanded some back salary for this expenditure of time, money and brain-fag in efforts to bring into use a modern economical convenience so widely needed as this? I am able to say that the protection I finally concluded to seek for will soon be forthcoming from the Patent Office at Washington.

NEW STANDARD ROADWAY ON THE PENNSYLVANIA RAILROAD.

The accompanying drawings and photographs show the design for the new four-track standard roadway which has been recently introduced on the Pennsylvania Railroad. In the summer of 1905 a committee of maintenance-of-way engineers of the road were appointed to experiment with different roadbeds and report on the best system to be used. The photographs show views along different portions of some 15 miles of experimental track built in accordance with these standard plans. The Pennsylvania will from now on gradually rebuild all of its main line tracks in this manner until eventually its entire main line is so constructed.

The new standards were designed with especial regard for drainage. As will be noticed in the drawings and photographs all side slopes in cuts are to be sodded or covered with vines. This sodded bank, in addition to presenting a much neater and cleaner appearance than the ordinary dirt slope, also acts as a very efficient aid to the better drainage of the roadbed. A heavy rain on a dirt slope always washes into the ditch great quantities of dirt and stone which clog it and not only prevent drainage and so damage the roadbed, but are a constant expense to the maintenance department in cleaning up. The water runs off the grass slope, however, without carrying with it this clogging material. The turf or sodded bank is generally brought directly to the ditch, but in places a dry toe wall of variable height may be built rising nearly perpendicular from the ditch, the slope starting at its top. This toe wall is shown dotted in the drawings.

As an additional precaution in wet cuts a French drain or cast iron pipe is placed in the ballast under the rails at frequent intervals.

Whenever a siding occurs, the distance from the center line of the road to the bottom point of the ditch is increased to 48 ft. 4¼ ins., the siding having a small roadbed of its own, separated and lower than the main four-track bed. This siding bed may be of gravel or cinders, and where necessary the drainage is cared for by 6-in. cast iron drain pipes running through the ballast of the siding parallel to the tie. The ditch at such places is made 1 ft. wider on account of the extra track.

Standards have also been devised for single and two-track lines. In the case of two tracks in a cut, the distance from the bottom of the side ditch to the center line of the roadbed is 18 ft. 4½ ins, the stone ballast is 13 ins. deep at the center line and 17 ins. deep on the side. The tracks are 13 ft. apart, c. to c., and the ditch is

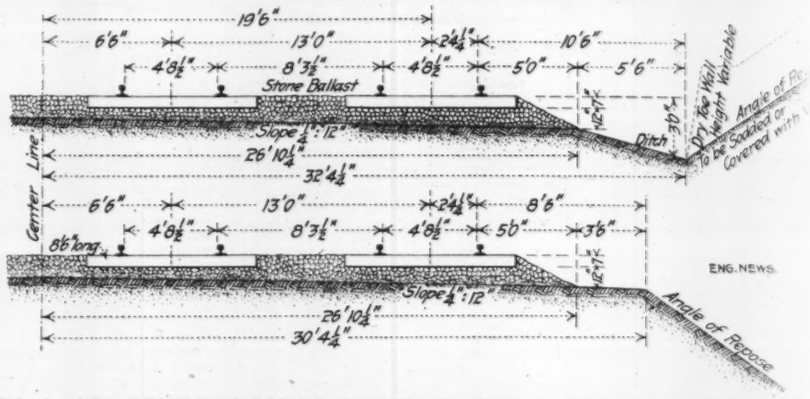

FIG. 1. NEW STANDARDS FOR FOUR-TRACK ROADBED ADOPTED BY THE PENNSYLVANIA RAILROAD.

On curves the low rail of all tracks to be of the same elevation.
Ballast to be 6 ins. deep below bottom of tie at center line.
In soft places cinder ballast to be used until roadbed has settled.
Berm ditches to be cut at top of slope on high side of cuts.
16 ties to each 33 ft. of main track, 14 for sidings and yards.
11,632 cu. yds. stone ballast per mile.

9 ft. 6 ins. wide in case there is no dry toe wall. There are 5,127 cu. yds. of stone ballast for every mile of double track.

For a single track in a cut the ballast is 15 ins. deep in the middle and 17 ins. deep on the side. The width of the ditch varies according to the weight of traffic on the single track, being narrower for light traffic. Its maximum width is 9 ft. 6 ins. and its minimum width 7 ft. 6 ins. The ballast may be stone or gravel. The allowance of stone ballast to the mile is 2,620 cu. yds.

RAILS AND PAVING OF STREET RAILWAY TRACKS.*

By B. J. T. JEUP.†

Most franchises granted in recent years to street railways contain provisions describing in general terms the kind of rail and the kind of paving between the tracks, but owing to the improvements that are being made in rails, track construction and paving the provisions are usually and naturally indefinite.

RAILS.—This indefiniteness, however, has given rise to a conflict of opinions between street railway officials and municipal authorities as to the kinds of r... comply with the terms of the contract and fran... after years of controversy opinions still dif... the kind of rail best suited for streets. As an ... at Columbus, Ohio, the traction company is very ... its determination to use the tee-rail, claiming ... safety in running its cars, while the city engineer ... municipal authorities advocate the use of groo... The question will probably have to be settled ... courts.

The railways advocate the use of the tee-rail ... erence to the grooved rails and present the ... arguments in favor of the former: (1) Less r... to traction; (2) better installation; (3) longer greater safety to traffic; (5) minimum track expense. The argument that appeals to municipal authorities is that of safety to traffic. High-speed interurban cars have deep-flanged wheels and the tendency is to adopt the M. C. B. form of flange, but danger has developed in operating these cars on street tracks having rails of the girder type or the old grooved rail. At Indianapolis, some of these cars used to run on their wheel flanges on the city tracks, and I have seen the tram of a comparatively new girder rail worn through in a short time by the grinding action of the flange. The railway companies also object to the grooved rail on account of the difficulty of keeping the groove clean.

Where the streets are wide and there is no teaming on the space occupied by the tracks it makes little difference, from the standpoint of the city, what kind of rail is used. But where the streets are narrow, the municipal authorities rightly demand a rail which offers the minimum obstruction to teaming, causes the least derangement or deterioration of the paving along the rail, and at the same time is safe for operation. In order to remove the objection made by the city of Indianapolis to the ordinary form of tee-rail, and to combine the advantages of the grooved and tee-rails, a special method of construction was adopted. A 7-in., 91-lb. tee-rail was made, and a deep groove is formed by a row of nose blocks laid as stretchers along the inner side of the rail, the space between these blocks being paved with ordinary vitrified paving blocks laid at right angles to the rails and nose

*Abstract of a paper read at the annual meeting of the Indiana Engineering Society, at Indianapolis, Jan. 17, 19, 1907.

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FIG. 2. VIEWS ALONG NEW STANDARD FOUR-TRACK ROADBEDS ON PENNSYLVANIA RAILROAD, SHOWING SODDED SIDE SLOPES IN CUTS AND LARGER DRAINAGE DITCHES.

blocks. There is some evidence of wear on the nose blocks, and a suggested improvement is the use of asphalt blocks which would be tough rather than brittle and consequently would not chip. This construction has met the approval of a number of engineers.

PAVING BETWEEN THE RAILS.—There are many forms of paving construction in use in Indianapolis: asphalt between the tracks, with a course of brick or granite stretchers on each side of the rail, or with headers alternating with two stretchers; we also have asphalt placed against the rail and against a Hayden block on the inside of the girder rail. With brick or stone pavement, the practice in this and other cities has been to put in new brick or block (or a cast-iron block) on the inside of the rail, with the paving between the rails laid in courses at right angles to the rail. The paving of the 18-in. strip on the outside of the rail has been of brick or stone block, laid either parallel with or at right angles to the rail. Some cities are using wood blocks between the tracks, but the experience in this city is unfavorable to their use. However well they may be treated, in a short time sufficient oil has exuded to enable them to absorb water and swell. Sheet asphalt, or any sheet paving, is as a rule unsatisfactory for paving between the tracks, and has given only partial satisfaction with heavy grooved rail construction. It is now the generally accepted opinion that the paving should be some form of block, so that it can be laid and taken up and replaced by the railway company when joints, ties or rail bonds are to be renewed. Such a pavement can also be repaired more promptly when the city requires, as the company need not await the convenience of paving companies to make the repairs. In Indianapolis, brick is now almost universally used for paving the space between the rails.

THE IMPROVEMENTS TO THE WATER SUPPLIES OF MARSHFIELD AND WAUPACA, WIS.*

By W. G. KIRCHOFFER.†

The cities of Waupaca and Marshfield are situated in the central portion of the State, and from a geological standpoint are located on the southern edge of the very large granite outcrop in Northern Wisconsin. A short distance south of these localities is found the northern limit of the Potsdam sandstone, which is the source of many artesian wells in Wisconsin.

WAUPACA.—For a number of years this city has been supplied with water from the Waupaca River, flowing through the city. This water was pumped by power developed upon the same river at the pumping station. The water was very turbid at times and was scarcely fit for domestic use a portion of the year. Besides this objection, the water was extremely cold in winter, so that the mains froze up very quickly where there was little or no circulation. During the cold winter of 1903-1904 the mains were frozen to such an extent that it cost the city nearly $8,000 to make the repairs the following spring.

The problems to be solved at this city were to secure for it a new source of supply that would be suitable for potable purposes and one of higher temperature in winter so that the mains would not freeze. As there was considerable objection made to the proposed improvements, the council passed a resolution to the effect that if the improvements would cost to exceed $14,000, the bonds voted for the purpose would not be issued, and the improvements would not be made. During the summer of 1904 the writer made an investigation of the conditions, and after making several test borings it was found that there was an extensive sheet of underground water flowing in the sand above the granite rock, in a general southeasterly direction.

Mirror Lake, and many other lakes about Waupaca, lie in depressions below this general water table. This fact was very apparent along the west bank of the lake, where it was proposed to develop the supply. The whole western bank of the lake was almost one continuous spring and the sand at this locality had an effective size of 0.22 mm. The temperature of this ground water was found to be 48° F., which was much higher than that of any of the lakes or the river. To keep the cost as low as possible, it was decided to use the water power at the old pumping station to operate the new pump (transmitting the power by electricity to the new location), and to develop the supply by the use of tubular wells.

At the chosen locality, 13 5-in. tubular wells, with 3½-in. points and 10 ft. long, were put down to a depth of 25 to 40 ft., depending upon the coarseness of the material. The points were covered with No. 60 wire and No. 8 sheet brass. The wells were spaced 10 ft. apart and connected to a horizontal suction pipe 6 and 8 ins. in diameter. This pipe was laid about 3 ft. below the surface of the ground and 1 ft. below water level, to prevent possible air leaks in the suction pipe.

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Peoria, Ill., Jan. 23, 25, 1907.

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The pumping station is located on the bank of the lake, adjacent to the wells, and is 18 ft. diameter, built over a pump well 8 ft. deep. The construction of this pit in the loose sand and the flowing water was very difficult on account of the limited amount of machinery and apparatus at our disposal. After the contractor had failed several times in his attempts to pump out the water and sand and to sink the brick wall, the writer took charge of the work and succeeded in sinking the wall of the pit by driving two of the large well points in the bottom of the excavation and removing the water without disturbing the sand.

The wall was lowered to the proper depth by removing the sand with shovels, and while the pit was thus practically dry the concrete bottom was put in place. This was not entirely successful, as the pit leaked considerably after the concrete had set, but the water could easily be kept out with a water siphon operated by water from the city main. After the new pump was installed it was attached to one of the well points, which was left in the center of the pit, and the water was thus kept down while another layer of concrete was put in place. This effectually stopped the leaks.

On account of the fact that the pump well was likely to be flooded from a rise in the level of the lake, and on account of its adaptability for a motor-drive, a high-lift centrifugal pump of the vertical type was chosen. This pump has a capacity of 700 gals. per min. against a head of 200 ft., when running at a speed of 850 r. p. m. The pump was driven by a 75-HP. direct-current vertical motor. At the old pumping station a 75-KW. 500-volt generator was installed and belted to the jack shaft of the two 72-HP. water wheels. The switchboard was so arranged that the pump could be started from this station and that in cases of emergency the pump could be operated from the current supplying the street railway, which is operated by the local electric light company. The city plant could in return operate the street cars if necessary. The transmission line from the power house to the sub-station consisted of two No. 0000 wires and one No. 10 starting wire. The same poles carry the wire for a private telephone line between the two stations, so that during the time of construction and making the tests, communication could be had with the operator at the power-house. The motor is controlled from the power-house, so it is only necessary for the operator to visit the sub-station once a day to see that all the bearings are properly oiled.

After the pump and motor were installed and in successful operation a test was made upon the plant to determine its efficiency and capacity. The best efficiency was slightly over 76%; the guarantee was 59%. All of the work, except the construction of the power-house, was done under the supervision of Mr. C. H. Phillips, who was then superintendent of the plant. The low cost of doing the work was largely due to his management and to the fact that the excavation of the trenches was all in white sand, except one block of granite rock on Elm St. The total cost of these improvements was $14,663.

MARSHFIELD.—For the last 13 or 14 years this city has been supplied with a ground water from a large round brick well and from wooden galleries or trenches connected to the well. This supply is from a bed of sand about 14 ft. thick and lying about 12 ft. below the surface of the ground. In the summer of 1904 the supply was increased by putting down 30 2-in. Cook well points into the same sand bed, about 500 ft. from the station. The supply has never been adequate and has constantly decreased from year to year.

The system of Cook wells increased the supply but little, so that now it is necessary to pump from these wells constantly night and day at the rate of about 60 gals. per min., besides what can be drawn from the old well. During the month of October, last year, the average daily pumpage was 198,000 gals. During the summer of 1906 the city voted to issue $35,000 in bonds to improve the water supply and purchase a new equipment for the electric light plant. In the latter part of August the writer was called in to advise the city what to do to provide a greater supply of water.

The city is somewhat peculiarly situated, as it is high and dry on a terminal moraine of one of the earlier glacial epochs and there is not a stream of water of any appreciable size within seven miles of the city. The only two plans possible were to go to the Yellow River, seven miles south, or to further develop the ground water supply. It was decided by the water commission to choose the latter source, and at the suggestion of the writer a number of test wells about 70 ft. deep were put down to granite on a line crossing the little valley in the vicinity of the pumping station. A stratum of sand and gravel lying just above the rock, much thicker and longer than that from which the present supply is taken, was found farther to the south. A large number of samples of sand taken from the wells were analyzed for size, and curves drawn to determine the effective size.

At test well No. 6 an underflow test was made with Professor Slichter's electrical method, and the direction and velocity of the water determined. The velocity of the underflow was extremely low, only 8 ins. per day, and the direction of the flow was about S. 65° E. After these tests were completed, the writer reported to the water commission on the advisability of using the water from the lower sand bed for a source of supply. The plan is now being carried out.

There are 16 tubular packed wells to be put down into the lower sand bed. The screens are to be as long as the depth of the sand at that place. The screens are to be made of 3½-in. wrought-iron pipe, punched with holes ⅛ × ⅝-in. and covered with No. 4 sheet brass. A 12-in. casing is used in putting down the wells, and when rock is reached the point and its connecting pipe are lowered in the well and the space about the point is filled with screened gravel 1/10-in. to ¼-in. in size. After the gravel is put in place the 12-in. casing is pulled out, leaving a screen with holes about ¾-in. diameter surrounded with gravel of the above size.

These wells are to be spaced from 35 to 40 ft. apart, and the horizontal suction pipe is to be laid 12 ft. 6 ins. below the surface of the ground and just above the surface of the ground water. The pumping station equipment is to be very similar to that at Waupaca, except that here we will use an induction motor, and that the total capacity of the plant when both pumps have been installed will be 1,200 gals. per min.

One feature of this work which is somewhat novel is that in addition to the natural ground water supply, we propose to supplement this with an artificial ground water supply. It is proposed to construct an earth dam across the small valley at the pumping station, which will impound the surface water flowing from an area of 417 acres. Within the reservoir thus made by the dam, two intake wells will be put down to the granite intersecting the same sand bed that supplies the system of packed wells from which the water is to be pumped. These wells will be put down in the same manner as those supplying the water to the pump, except that they will have no screens and the entire hole from the rock to the surface of the ground will be filled with coarse screened gravel. Over the wells will be constructed a small filter, which will remove any sediment in the water and provide an intake for controlling the water flowing into them.

From this source it is estimated that a minimum of 90,000,000 gals. of water per year could be obtained, and that, including the probable percolation upon the drainage area, an average daily supply of 556,000 gals. could be obtained. As the present average daily consumption is only 167,000 gals. this artificial ground water will furnish over three times this amount, without considering the amount of water that may be drawn directly from the lower sand bed. The work of drilling the wells, lowering the screens and vertical suction pipes in place and drawing the casing is being done by contract at $2.35 per ft.

A CONCRETE PILE FOUNDATION for a four-story laundry building of G. L. Hooper & Sons, Salem, Mass., has the following features. The foundation of each column of the building consists of a group of four Raymond piles, arranged in a square, 3 ft. on centers. These are capped with a 24-in. concrete slab 5 ft. 6 ins. square (projecting 15 ins. beyond pile-center) into which the piles project 6 ins. The building has reinforced concrete columns, floors and roof, and concrete block walls. A chimney at one corner of the building, 48 ins. in diameter by 100 ft. high, also of concrete, foots on a base of 9 piles, each of which has a central steel rod carried up into the concrete wall of the chimney to give anchorage. The piles used for this building average 20 ft. in length (14 to 37 ft.) after cutting off, and have a diameter at point of 6 ins. and a taper of ⅖-in. per ft. (so that a 21-ft. pile is 20 ins. at top). The steel cores which were used to make the holes for the piles were driven with a 3,000-lb. Vulcan steam hammer, falling about 3 ft. and delivering 60 blows per min. They were driven until one inch of penetration required 8 to 10 blows. The steel shell surrounding the core is No. 18 gage, and this is left in the ground after the core is withdrawn. The concrete filled into these shells was made of 1 part Lehigh Portland, 3 parts sharp sand and 5 parts 1½-in. crushed stone. The original design of the foundation called for wooden piles. These would have required cutting off at low-water, 7 ft. lower than the tops of the concrete piles, and would therefore have required much concrete for piers. Moreover, the presence of old wharf piles and timbers in the subsoil would have led to the injury of many of the wooden piles in driving. The concrete piles (172, averaging 20 ft. long) were contracted for at the rate of $1.50 per lin. ft., with a price of $1.40 per lin. ft. for excess over a specified total; the owner, through the general contractor, provided a level space for the pile-driver, made all excavations, braced the trenches, etc. The work occupied only 16 working days after the driver was once in position. The Raymond Concrete Pile Co., Boston, Mass., put in the piles, under the direction of the architects, Baillinger & Perrot, of Philadelphia, Pa.

THE UNION LOOP OF CHICAGO AND A PROPOSED TERMINAL STATION SYSTEM FOR THE ELEVATED RAILWAYS OF CHICAGO.

By J. B. STRAUSS.*

The Union Loop of the elevated railway system of Chicago is a two-mile double-track elevated structure, in the form of a parallelogram, enclosing thirty-five blocks in the central business district. It has 11 stations, situated approximately two blocks apart, each station having accommodations for four trains simultaneously. The Loop thus provides each of the four elevated railway systems of the city with an independent down-town circuit, and with 11 loading and unloading stations uniformly distributed through this district. The Loop is operated by a separate and distinct company, to which the elevated lines pay rental.

THE PRESENT CONDITIONS.

Referring to Fig. 1, which shows the central business district of Chicago with the Union Loop as it exists to-day, it will be noticed that the elevated railways connect with the Loop as follows:

The South Side Rapid Transit turns east at Harrison St. into Wabash Ave. and enters the Loop from the south at Van Buren St., changing there from the east to the west track; continues north on that track to Lake St., west on the south track on Lake St. to Fifth Ave., south on the east track on Fifth Ave. to Van Buren St., east on the north track on Van Buren St. to Wabash Ave., and thence south again on the west track to the main line.

The Metropolitan West Side Elevated enters the Loop at Fifth Ave. and Van Buren St., changing there from the south to the north track; continues west to Wabash Ave., turning into the west track on that street, and follows up the south side line as far as Fifth Ave and Van Buren St., turning back there to the west and the main line. Thus the Metropolitan and the South Side run on the inner track of the loop, in left-handed or anti-clockwise direction.

The Chicago & Oak Park Elevated, and the Northwestern Elevated, run on the outer track of the Loop, in right-handed or clockwise direction. The former enters from the west at Fifth Ave. and Lake St., leaving at the same point, while the Northwestern enters at the same point from the north.

ALINEMENT AND CROSSINGS.

The South Side line has a sharp reverse curve at Harrison into Wabash, and where it enters and leaves the Loop at Wabash and Van Buren it crosses the line of the Oak Park and Northwestern lines on curve. Similarly the Metropolitan has a sharp reverse curve at Market St., and crosses the Oak Park and Northwestern lines on curve where it enters the Loop, at Fifth Ave. and Van Buren St. The Northwestern line crosses the Oak Park line at right angles at Fifth Ave. and Lake St., but the entry of these two lines at that point is direct and involves no special alinement. Switch and signal towers are located at each of the three cross-over points.

TRANSFERRING.

The most direct transfer from the South Side Rapid Transit to the Metropolitan Elevated is at Adams and Wabash; from the South Side and the Metropolitan to the Oak Park and Northwestern Elevated at Fifth Ave. and Randolph; from the Oak Park and Northwestern Elevated to each other and the Metropolitan Elevated at Randolph and Wabash; from the Oak Park and Northwestern Elevated to the South Side Rapid Transit at State and Van Buren, and [illegible] the Metropolitan Elevated to the South [illegible] Rapid Transit at La Salle and Van Buren. [illegible]station at State and Van Buren Sts. is not [illegible]official transfer point, the La Salle St. sta[illegible] being used instead. None of the Lake St. s[illegible]s are available as transfer points, since th[illegible]re not provided with cross-overs above the s[illegible] level.

It will be seen that, in transferring [illegible] the South Side Rapid Transit to the M[illegible]olitan Elevated, the passenger rides 7 block[illegible]rther north than necessary, and back again, [illegible] total of 14 blocks out of his way before he m[illegible]s any real progress toward his destination. [illegible]larly the passenger from the Oak Park and [illegible]North-western Elevated bound for the Met[illegible]olitan or South Side lines rides 5 blocks far[illegible]e east and 1 block farther south than necessa[illegible], or a total of 12 blocks out of his way before [illegible]s real progress begins. The transfer from [illegible] Oak Park to the Northwestern Elevated, and vice versa, in the same way, involves a useless ride of 24 blocks. The transfer from the South Side and Metropolitan lines to the Oak Park and Northwestern lines, on the other hand, involves very little retrograde movement, and the same is true of the transfer from the Oak Park and Northwestern lines to the South Side line, while there is no retrogression whatever in the transfer from the Metropolitan to the South Side Rapid Transit.

With respect to the Chicago, Rock Island & Pacific Railway depot at La Salle St., the only depot on the Loop, arriving passengers for the South Side, the Oak Park and the Northwestern lines suffer no loss of time. Departing passengers, however, whose time is generally most limited, are compelled to ride 17 blocks out of their way on the South Side, and 8 blocks out of their way on the Oak Park and Northwestern

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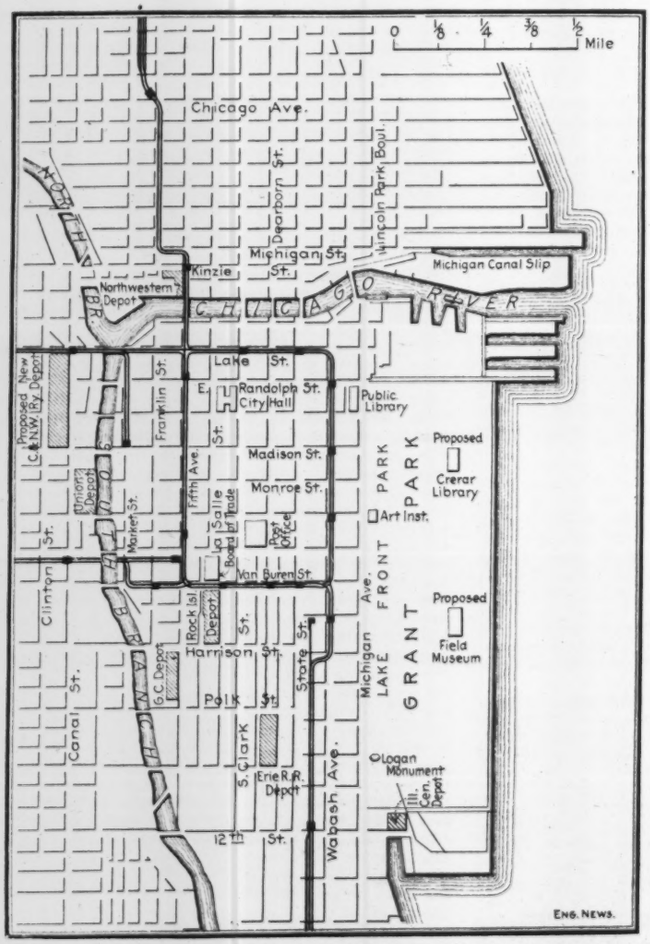

FIG. 1. THE UNION LOOP AND ITS CONNECTIONS WITH THE FOUR ELEVATED RAILWAY LINES.

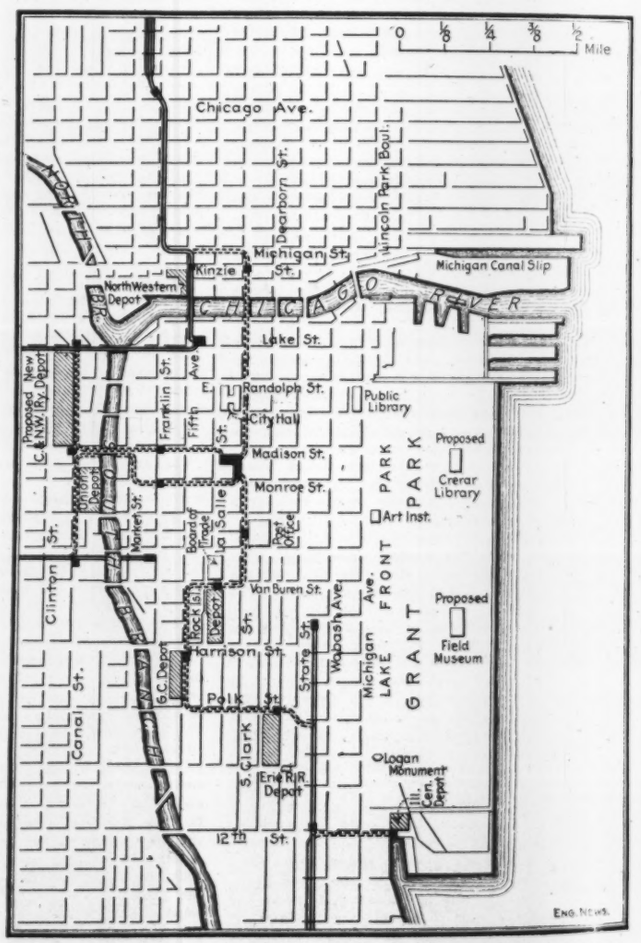

FIG. 2. THE TERMINAL STATION SCHEME; UNION LOOP REMOVED.

MAP OF CENTRAL PART OF CHICAGO, SHOWING THE UNION LOOP OF THE ELEVATED RAILWAYS, AND A TERMINAL STATION SCHEME DEVISED BY J. B. STRAUSS.

lines respectively. Departing passengers on the Metropolitan make direct connection; while arriving passengers on the other hand, are compelled to ride 22 blocks out of their way. Access to the various public buildings presents the same phenomenon, the Post-office, City Hall, County Building, and most of the principal office buildings being a considerable distance within the Loop. Five of the six great railway depots are so far outside of the Loop that the surface car and 'bus lines must be depended upon for transportation between them and the Loop.

The South Side Rapid Transit has a very poor and unsightly secondary station, or substation, at Congress St., but the Metropolitan has a new and efficient sub-station on Fifth Ave., near Van Buren. The other two lines have no such means of relief, and depend altogether upon the terminal facilities of the Loop.

TRAFFIC CONGESTION.

While these inherent deficiencies and shortcomings have existed from the outset, there was, strange enough, no serious complaint until recently, when the introduction of express service on the South Side Rapid Transit and the extension of both this line and the Northwestern Elevated brought matters to an acute stage.

At the present time during the rush hours both Loop tracks are completely filled with trains from one end to the other, and progress is consequently so slow that the circuit occupies from 20 to 30 minutes instead of the 13 to 15 minutes allowed by schedule. The station platforms meantime are packed to the danger point, and the trains themselves, though filled to overflowing long before one-fourth of the circuit has been traversed, creep along from station to station, receiving additional human freight at each, in spite of the fact that the limit of comfort and safety has long been exceeded. The city is now attempting to police the Loop stations and limit the number of passengers carried by each train, which, while undoubtedly warranted as a measure for greater comfort and safety, absolutely destroys whatever slight value the Loop possessed as an element of rapid transit.

PROPOSED REMEDIES.

Two suggestions have been made for remedying existing conditions. One proposes a lengthening of the Loop platforms so that two trains of each system can be accommodated at each station at a time. The other provides for through routing of a part of the trains, so that the number of trains making the complete circuit will be reduced. Both were recommended by Mr. B. J. Arnold in a report* to the City Council, dated March, 1905. The extension of the platforms was actually begun, but was stopped by the Corporation Counsel, on the ground that the permit was illegal. The city is ready to permit the extension of the platforms if the companies will agree to through routing, but this the companies refuse to do, on the ground that it is impracticable, and so the situation remains unchanged.

As a matter of fact, both proposals are only partial remedies. As the ramifications of the feeder lines increase, the tax upon the loop will become greater and greater, far beyond the possible limits of platform extension or of through routing or both. The fundamental defect of the loop is that it provides only two tracks to accommodate the traffic of eight. It seems to have escaped both the designers and the operators of this railway that it is impossible to merge four railway lines of a total length of over 100 miles into one of only two miles length, particularly on such schedules as it is necessary to maintain during the rush hours.

In addition to this fundamental defect, there are the three grade crossings, reference to which has been made, and which greatly restrict the capacity of the loop. If these are remedied by double decking, as has been suggested, there would still remain the loss of time resulting from the 44 separate stops of the loop trains for each loading, or from 88 stops if the platforms are lengthened as suggested. Through routing would reduce this to some extent, but is open to some serious objections. Secondary loops, as have been proposed, would help a little, but neither one, nor all of these, would be a complete and satisfactory remedy, and would cut up and disfigure the city beyond redemption.

THE TERMINAL STATION PLAN.

It appears to the writer that the best thing to do with the loop is to remove it altogether and replace it by a terminal station, centrally located, with an independent double-track entry for each of the four lines, and by four secondary terminal stations, one for each line.

Fig. 2 shows the central business district with the loop removed and the proposed system in place. The main terminal is located, for the sake of illustration, in the half block bounded by Clark, Monroe and Madison Sts. The Northwestern Elevated line is to be diverted to the east at Kinzie St., continued to Clark, and then directly south, entering the main terminal at Madison St. The Oak Park and Metropolitan lines are to be brought into Canal St., running south and north, respectively, to Madison St., thence east on a four-track structure to Market St. At this point the two lines are to separate, the Oak Park continuing east on Madison, and the Metropolitan turning south, then east in Monroe St., the two roads entering the main terminal at the northwest and southwest ends, respectively. The South Side line is to turn west at Polk St., continuing to Fifth Ave., thence north to Van Buren, thence east to Clark, thence south, entering the main terminal at Monroe St. The present tracks of the Northwestern and Oak Park lines are to be continued to a combined secondary station at Lake St. The present secondary station of the Metropolitan is to be maintained, and similarly that of the south side, except that the latter should properly be rebuilt on the company's property on Congress St. instead of over the street, and two stub-tracks provided instead of one. Street stations are to be provided at Plymouth Court and Polk St., Fifth Ave. and Harrison, Van Buren and La Salle, Clark and Quincy, Clark and Randolph, Clark and Kinzie, Franklin and Monroe, Franklin and Madison, and Canal and Madison.

It will be seen this system furnishes four main outbound and four main inbound tracks, instead of one outbound and one inbound, as at present. It also gives four secondary outbound and four secondary inbound tracks, instead of one secondary outbound and one secondary inbound and one secondary outbound and inbound combined. In other words, the trackage alone is increased to more than three times that afforded by the loop. As regards loading capacity, the number of stub-tracks in the main station can be regulated to suit. The writer assumes that 20 such tracks could be provided, 5 for each line, so that 20 five-car trains could be loaded simultaneously on, we will say, a one-minute schedule. Assuming 60 persons seated per car, and *none standing*, this would permit the transportation of 6,000 × 12 = 72,000 passengers per hour, whereas the total carried by the Union Loop in the two hours between 5 and 7 o'clock in the evening averages 64,000, with cars crowded in excess of 100 each.

Aside from the increased trackage and increased loading capacity effected by the proposed system, the elimination of the loop grade crossings, of its reverse curves, of its frequent turns, and the many station stops, will greatly reduce the running time and permit a schedule faster by probably 50% than that now possible. The elimination of these factors also greatly reduces the danger of accident which is ever present in a system where from 50 to 100 trains cross and re-cross each other every hour of the day.

The change in alinement of the South Side rapid transit puts the Dearborn St. Depot, the Grand Central Depot and the Rock Island Depot directly on this line, while the Illinois Central Depot can be connected with it by an elevated moving sidewalk or similar device. The new Chicago & Northwestern Depot and the Union Depot would be directly on the line of the Oak Park and Metropolitan lines, while the old Northwestern Depot would be reached by the Northwestern Elevated. The Court House, City Hall and Post Office are also on the direct lines. Passengers from any system can reach these points by direct travel, without losing time in retrograde travel.

The length of track of each road is reduced, except possibly that of the South Side Rapid Transit, which, because of the necessity of serving three railway depots, is not so direct as it might be. The main terminal station is within a few minutes' walk of the central business district, and the various secondary terminals and the street stations serve the remoter parts.

The elimination of the loop would wipe out the congested loop district and would extend the business area from Kinzie to Polk St. and from the lake to Canal St. It would equalize and increase property values throughout this area. It would free the district east of Clark St. of all overhead work and all noise and obstruction. Wabash Ave. would have no limitation to its growth, and in time would become an outlet for overcrowded State St.

Through routing, if found desirable, could be put in effect at any time, and would require no such awkward expedient as double-decking. The writer believes, however, that a system of universal transfers would be more satisfactory. The change from one system to another would be made at the main terminal with ease, comfort and dispatch, and a transfer system could undoubtedly be enforced with less friction than any plan of through routing.

As regards the present elevated structure itself, nothing more unfit for city use could be imagined. It presents the maximum obstruction to street travel, is an affront to the eye and torture for the ears and nerves. The floor is not the solid ballasted floor used for track elevation work, even in the outlying districts, but the cheapest type of open wooden floor, such as is used in railway bridges outside of the city limits. No means whatever are used to reduce the noise, and at the crossing points this is augmented by the cross-overs and the pneumatic switch and signal systems. No means other than the ordinary guard timbers are used to prevent trains from leaving the structure in case of derailment, and the character of the loop curves has caused five or six derailments in the past few months.

The writer would eliminate these objectionable features by building the new portion of the elevated work of reinforced concrete with an open-ballasted floor, as designed by the writer and shown in Mr. Arnold's report. This type of structure is permanent, and its appearance does not detract from any street. The side enclosures make it absolutely safe as regards derailment, and the open floor reduces the darkening of the streets. It is nearly noiseless, and if the rolling stock is improved and provided with suitable truck enclosures, all trouble from noise will be practically eliminated. Such portions of the present structure as would not require replacement are to be reconstructed along the lines of the new structure. As regards the main elevated lines themselves, no change whatever would be required, but no improvement of terminals should be permitted without an agreement to replace the present elevated floors throughout the city with some satisfactory type of noiseless floor.

It is, of course, obvious that the main terminal station could be designed with a view to its use in a similar capacity for a possible future subway system. Accommodations may also be provided, if deemed desirable, for one or more of the nearby surface lines, thus leaving Clark St., for instance, free for team traffic. The upper portions of the structure would be available for office purposes. The design of the terminal proper, to meet the rather exceptional traffic requirements, is merely a question of depot architecture, rendered easier by the notable work done in that direction in the past few years in connection with our great metropolitan railway terminals.

Looking at the other side of the question, two or three objections against the proposed system might be urged. The first is that some of the patronage now enjoyed by the South Side Rapid Transit might be diverted to the Illinois Central

*Abstracted in Engineering News, March 23, 1905, p. 328.

R. R., which has a suburban station on the lake front at Jackson Boulevard and another at Randolph St. The former, however, is at a disadvantage as compared with an improved Congress St. sub-station for the South Side Rapid Transit, to which all the territory between State St. and Michigan Ave., as far north as Adams St., is directly tributary. The Randolph St. station of the Illinois Central R. R. is handier to the extreme northeast section of the down-town district, but this section is relatively of lesser importance from a traction standpoint than the remaining sections, which are all closer to the main terminal than to the Illinois Central stations. Further than this, it should not be forgotten that it is not the down-town terminal, but the convenience of the destination points, which determine the patronage of a suburban or rapid-transit line. The Illinois Central, Rock Island, Chicago & Northwestern, Chicago, Milwaukee & St. Paul, and the Chicago, Burlington & Quincy railways are all at a disadvantage compared with the Union Loop as regards location of terminals near the business district, but nevertheless they enjoy a large and regular patronage, which is as unaffected by the elevated roads as that of the elevated roads is unaffected by them.

The second objection involves a question as to the practicability of a union station from an operative standpoint. The question should be answered by the experience of the steam roads, previously referred to, as well as others, whose enormous commuter traffic is all handled from terminal stations. If this is possible for steam roads, hampered as they are by the necessity of maintaining unimpaired facilities for through passenger traffic and for freight, there can be no doubt that a station designed and maintained solely for suburban traffic and electric operation is entirely practicable and satisfactory, not only for the present demands of the loop patronage, but also for those of the future.

Other objections which present themselves are the cost of the undertaking, the difficulties of securing consents, and similar considerations. These the writer does not regard as serious, in view of the certain returns, both financial and otherwise.

The indicated routes and locations can be altered considerably without affecting the general proposition, and if necessary the alleys may be used in place of the streets, at least in part, although this would probably involve double-decking. These are matters of detail which can be settled after a thorough study of the situation has been made.

While it is not possible, of course, to devise any plan for betterment which will be altogether free from objection, the writer presents this, in the belief that it is freer from objections than any other so far offered. All will agree that betterment is imperative, and that the plan finally adopted should not be a half-hearted measure, but one which will strike at the root of the trouble, and in eradicating it give Chicago an elevated railway terminal system which will meet its needs now and for all time.

THE CONDITION OF THE STEEL WORK IN A SAN FRANCISCO BUILDING ERECTED 13 YEARS AGO.

By FRANK B. GILBRETH,* M. Am. Soc. M. E.

The removal of the upper six stories of the eight-story† Mutual Life Insurance Company building, located at the southeast corner of Sansome and California streets, San Francisco, Cal., offered an unusually favorable opportunity for noting the effect of rust, earthquake and fire on a steel-frame structure that had been standing for thirteen years. This building (Fig. 1) was erected in 1893. It was particularly well designed for those times, and the workmanship was of the highest class throughout. The mortar was not of the best quality, but the workmanship of the brick, stone and terra-cotta laying and the filling of all the joints with mortar was as nearly perfect as possible. The designing was done and the construction superintended by Mr. Clinton Day and Mr. Nathaniel Blaisdell, two well-known architects, who stand in the first rank of their profession in San Francisco.

All walls were self-supporting. They had granite facing in the two lower stories, while the upper six stories were common red clay brick faced with Roman-size yellow brick and with a large amount of ornate yellow terra-cotta, including also a heavy terra-cotta cornice that projected more than 4 ft. The exterior walls were built around a steel frame with bolted connections, which was also self-supporting, and which, together with the interior steel columns carried all the weight of the floors, interior partitions, etc. The floors were made of hollow terra-cotta short-span straight arches, covered with lean cinder concrete, in which the wooden floor screeds were imbedded in the usual manner. The partitions were hollow terra-cotta blocks.

EARTHQUAKE DAMAGE.—The testimony of the janitor and several tenants was that the earthquake did almost no damage to any part of the building. Such damage as occurred was limited to a few small pieces of plastering that fell down. There was no evidence gathered during the taking down of the building that would tend to show that the building was in the injured structurally by the terrible earth

FIRE DAMAGE.—The effects of the fir no different than those of Baltimore, Slou Rochester and Toronto, all of which prece a much smaller scale, the fire of San Fra The granite in the lower two stories wa badly spalled where the heat came out windows, but it was nearly intact where th was inward, as around the entrance to the stairway. The beautiful marble hallway wreck from bottom to top. The marble rooms were completely destroyed by he pansion cracks, although they contained no bustible material whatever.

FIG. 1. MUTUAL LIFE INSURANCE CO. BUILDING, SANSOME AND CALIFORNIA STS., SAN FRANCISCO, CAL.

Sansome St. Front viewed from Merchants' Exchange on Oct. 28, 1906, during removal of six upper stories for rebuilding. The walls, partitions and most of the floor arches have already been taken down. The wreckage of the intermediate roof-truss over the deep central part of the eighth story has also been removed. A stiff-leg derrick is being set up on the eighth floor, using an old wooden flagstaff as gin-pole.

Common clay red bricks stood the heat better than any other clay material. The yellow Roman-size brick and the yellow ornamental terra-cotta were very unsatisfactory, but stood much better than did the granite or the hollow partition tile blocks.

Both floor blocks and partition blocks showed most conclusively that, while terra-cotta is in itself incombustible, it is a very unsatisfactory material to use in connection with steel, as its coefficient of expansion by heat is so much greater than that of steel that it fails by buckling due to expansion long before it is ruined by fire or by water. Furthermore, those floor arches that

*34 West 26th St., New York City.

†The central portion of the top story of this building was twice the height of any other story, and was occupied by the Merchants' Club. The side portions had an intermediate floor between the eighth and the roof, and the building might therefore be rated as nine-story.

apparently were but little injured, were not as sound as they appeared. Some of them sagged, little by little, as much as 4 ins., requiring constant attention while taking down the building; in many cases the laborers slumped through them while walking on the floors. It being so dangerous, it was finally deemed advisable to cover over

FIG. 2. APPEARANCE OF INTERIOR AFTER REMOVAL OF LOOSE RUBBISH.
View at Elevator Shaft, Fifth Floor.

the first story of the building with planks to the thickness of 18 ins. to prevent possible accident in the Canadian Bank of Commerce, which occupied without interruption the lower story of the building.

Many kinds of plastering were used throughout the building. None of it stood well. There was no plastering of Portland cement in the building. The Portland cement sidewalk and steps stood exceedingly well.

Although there was but little wood used in the building, yet together with the office furniture and fittings it was sufficient to burn up every combustible thing and to create a draft sufficient to remove all traces of wood ashes. With this interior heat, aided by the intense and lasting heat of the conflagration on the exterior, the walls expanded in various directions, completely shearing some of the bolts of the steel frame. It is known that this shearing was due to the fire and not to the earthquake, for the reason that the shearing is found only at or very near the points of the expansion cracks.

CONDITION OF STEELWORK.—The steel frame furnished the most interesting subject of the entire building. When it was known that the writer had the contract for removing the top six stories of a 13-year-old steel-frame building, we were besieged from all quarters for information. Engineers and architects inquired about the condition of the frame. Paint manufacturers and dealers wrote to find out what kind of paint was used to prevent rusting. Advocates of certain so-called "systems" of fireproofing wanted data regarding steel in contact with cinder concrete.

All plans and specifications of this building were destroyed in the great conflagration, and consequently the original specifications cannot be quoted, but it is reasonably safe to state that the paint used was ordinary red metallic paint. Where this paint was in contact with lime mortar the steel was in very good condition, with little indication of rust. The walls in the top story and above the roof of the building were laid in a mortar containing a larger proportion of Portland cement than that of the lower stories, and under similar conditions there seemed to be less rust where Portland cement and lime were used than where lime alone was used. There was no place observable where mortar with no lime in it was used.

It must be remembered that, as already stated, the joints in the brickwork were exceptionally well filled, and this means that the mortar was generally, in fact almost without exception, well filled around the columns, but there were some instances where the ornamental terra-cotta facings prevented the mason from slushing in the mortar as well as he could around the columns. In one of these cases there was a piece of rust scale larger than a man's hand, and so firm that it would stand handling by one of its corners. This was the very rare exception and the beams it came from would even now stand fairly well in comparison with the average steel beam that has been carried in stock in a steel yard for several months. Figs. 3 to 7 are representative views of the steelwork as it was found during the work of demolition.

There were occasional instances where there was some rust under the paint, probably due to the fact that the steel was not thoroughly cleaned before painting. These cases were comparatively rare, but with these exceptions the rust had not developed in thirteen years beyond a negligible amount, in fact all of the straight columns, beams, tie rods and bolts have been sold for use in new buildings now in progress of erection.

FIG. 3. A COLUMN SPLICE AND THREE FLOOR BEAM CONNECTIONS, SHOWING PRACTICALLY NO RUSTING (CINDER CONCRETE).

The following conclusions the writer believes to be unquestionably correct:

1. A steel frame, properly painted and buried in masonry, will not rust enough in thirteen years to affect its strength any measurable amount.

2. The better the steel is coated with mortar the less it will rust.

3. Portland cement is better than lime mortar for imbedding steel to prevent it from rusting.

4. Unpainted iron rods buried in mortar composed of lime and a large proportion of Portland cement rust very little, certainly not enough to impair their strength.

5. Columns should be of such cross section that they can be thoroughly imbedded in Portland cement, avoiding a hollow column unless latticed and filled with very soft concrete.

6. Wherever possible, preference should be given to those shapes of steel that present the least surface to the action of rust.

7. If steel is not thoroughly cleaned from rust before it is painted, the paint will not greatly retard the progress of the rust.

8. It is much easier to cover steel thoroughly with concrete than with brick masonry. If brick masonry is to be used the bricklayer should thoroughly plaster the steel work ahead of the brick work.

9. The quality of the paint used, though important, is not so important as surrounding every part of the steel with Portland cement.

10. Interior columns do not rust as much as exterior columns.

11. Cinder concrete does not injure to the slightest degree a steel floor beam that has been painted.

12. No pipes or wires should ever be placed behind fireproofing, as they will buckle from the heat and push off the fireproofing.

13. This building probably could have been saved intact if it had had fireproof exterior door and window-frames with wire-glass and an emergency water-tank on the roof.

14. Terra cotta blocks are not as good as concrete for fireproofing interior columns, nor do they protect the steel from rusting as well as does Portland cement concrete.

15. Neither marble nor any of the well-known kinds of plaster will withstand heat. There is a tremendous demand for some durable material that can be worked as easily as can wood or plaster, but that will resist great temperatures.

16. There is no reason to fear structural damage in tall buildings, in San Francisco or anywhere else, by a recurrence of earthquake as severe as that of April 18, 1906, provided these buildings are properly designed and properly constructed, since this building, which was taller than the average ten-story building, and was built on made land, went through the earthquake without a structural blemish.

SPREADING RAILS ditched a through freight train on the Baltimore & Ohio R. R., at Longdale, W. Va., Jan. 24, and killed three trainmen. Fourteen cars went over the embankment.

THE EFFECT OF THE CHICAGO DRAINAGE CANAL ON THE LEVELS AND NAVIGATION OF THE GREAT LAKES.

An important and interesting report on the Chicago Drainage Canal has been made by the International Waterways Commission.* The net outcome of the report is the recommendation that the diversion of Lake Michigan water through the Drainage Canal be limited to 10,000 cu. ft. per sec., and that the sewage of the Calumet

Fig. 4. A Wall-Column Broken Off by Fall of Roof Truss Over Central Part of Eighth Story; Attachment of Lower Chord of Truss.

No material rusting appears on either column or truss.

District be purified and allowed to find its way into Lake Michigan through the river instead of being diverted to the Drainage Canal. The conclusions in favor of sewage treatment are based on a report by Messrs. Rudolph Hering and George W. Fuller, of New York. This report, which includes a review of available plans for treating the sewage of a population of 1,200,000, is abstracted elsewhere in this issue. In addition to the report of Messrs. Hering and Fuller, there is included in the report of the International Waterways Commission a number of documents bearing upon the subject matter of the main report, including copies of the various permits issued by the Secretary of War to the Sanitary District of Chicago for the diversion of Lake Michigan water through the Drainage Canal.

The opening part of the report describes the Chicago Drainage Canal and outlines the various investigations and legislation that preceded its construction. As is generally known, Chicago was originally built on the river of the same name. Its sewage was discharged into Lake Michigan and its water supply taken from the lake from the time that the first sewerage and water-works systems were built. Through various annexations, the area of Chicago has been greatly increased, and at present the population is rapidly extending into the Calumet River District.

Early in the history of Chicago advantage was taken of the Illinois & Michigan Canal to divert a portion of the sewage of the city from Lake Michigan to the Mississippi River by way of the Des Plaines and Illinois rivers. The divide between the two great drainage systems is within some ten miles of Chicago, and has two depressions which are only some 10 ft. above the surface of the lake.

The Chicago Drainage District, with an area of 185 sq. miles, about 43 of which are outside the city limits, was created by legislative act in 1889, and the trustees held their first meeting on Jan. 18, 1890. In the following ten years the canal was designed and constructed. It was put in operation in January, 1900. The canal was designed to have a capacity of 600,000 cu. ft. per min (10,000 cu. ft. per sec.), with a velocity of 1.25 miles per hour in earth and 1.9 miles per hour in rock. The capacity was based on the assumption that in order to prevent nuisance it was necessary to dilute the sewage to the extent of providing 3½ cu. ft. per sec. for each 1,000 persons discharging sewage into the canal.

As the canal was actually built the full capacity was not provided except in the part cut through rock, and here, owing to the smooth sides produced by the use of rock channeling machines in the excavation work, the capacity has been found to be 14,000 cu. ft. per sec., instead of the 10,000 cu. ft. computed on the assumption that the sides would be rough rock.

The canal has a total length of 28.05 miles and a minimum water depth at low stage of Lake Michigan of 22 ft. The rock section is 15.95 miles long, 160 ft. wide at the bottom and 162 ft. wide at the top. A portion of the earth section, 5.3 miles long, is 202 ft. wide at the bottom and has side slopes of 2 to 1. The remainder of the canal, also in earth, is 7.8 miles long, and as originally built was 110 ft. wide at the bottom, with side slopes of 2 to 1. This section is to be enlarged to a bottom width of 200 ft.

The channel of the Chicago River is not sufficiently large to pass 10,000 cu. ft. per sec. to the canal without creating velocities that would be a hindrance to navigation. Thus far the Secretary of War has authorized the passage through the river of only 4,167 cu. ft. per sec. The engagement of the river to the end that an increased volume of discharge may be allowed has been

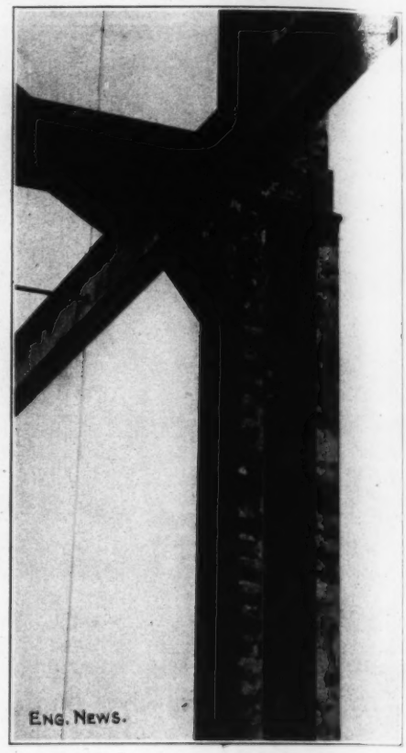

Fig. 7. Appearance of a Wall-Column after Removing Masonry.

Floorbeam connections at fifth floor level. The column, floorbeams and details show an excellently preserved surface.

undertaken by the trustees of the Sanitary District.

In 1903 the Illinois Legislature enlarged the Sanitary District by annexing 78.6 sq. miles on the north shore and 94.48 sq. miles in the Calumet District, making a total area of 358.08 sq. miles. At the same time the development of water power by the District was authorized. The plans for the North Shore District involve two additional conduits from the lake to the north branch of the Chicago River, but the water thus conveyed will not increase the discharge through the Drainage Canal beyond the 10,000 cu. ft. per sec. already contemplated. In order to serve the Calumet District, however, it is now proposed to

*The members of the Commission are as follows: O. H. Ernst, Brigadier-General, U. S. Army, retired, Chairman American Section; George Clinton, E. E. Haskell, Members American Section; George C. Gibbons, Chairman Canadian Section; W. F. King, Louis Coste, Members Canadian Section; W. Edward Wilson, Secretary American Section; Thomas Côté, Secretary Canadian Section. The report is dated Toronto, Ont., Jan. 4, 1907, and addressed to the Secretary of War of the United States and to the Minister of Public Works of Canada.

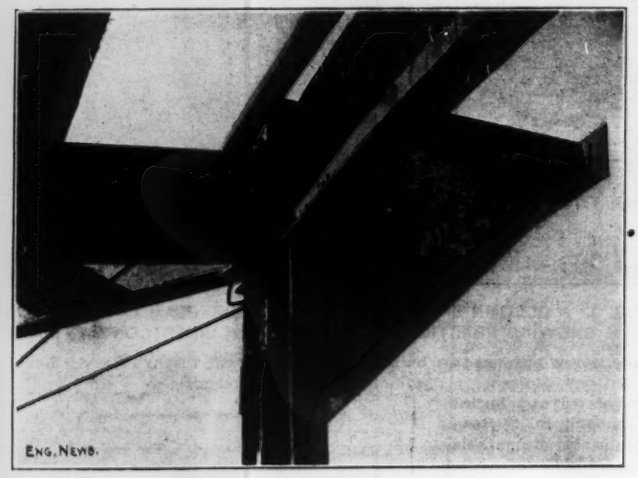

FIG. 5. CORNICE BRACKET AT ROOF LEVEL.
The web-plate and flange-rivets are badly rusted.

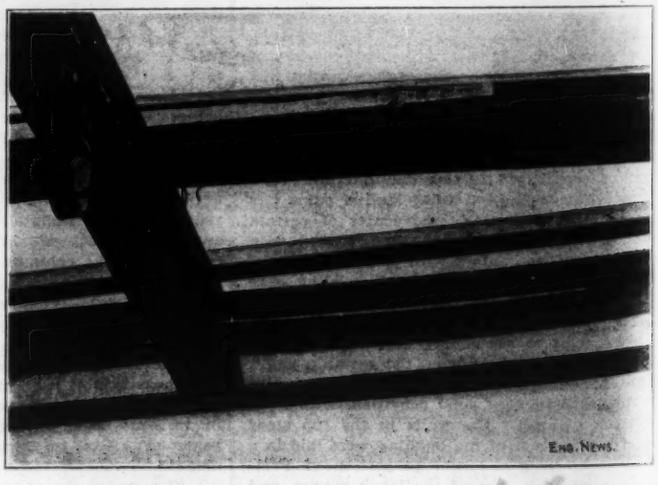

FIG. 6. EXCELLENT PRESERVATION OF BEAM WHICH WAS PARTIALLY BURIED IN CINDER CONCRETE.

dig a branch drainage channel, with a capacity of [illegible],000 cu. ft. per sec., thus providing for the utilization of the extra rock cut capacity of the canal gained by the use of the channeling machines already mentioned. The Calumet River branch channel would have a bottom width of 72 ft., with side slopes of 5 to 3 where in earth and a bottom width of 90 ft., with vertical sides where in rock; the depth in each case to be 25 ft.

Up to the date of the report nothing had been done toward the drainage of the North Shore and Calumet districts further than to make surveys and plans. The total expenditures on the Drainage Canal and accessories up to Dec. 31, 1905, including interest, have been over $50,000,000, of which $40,874,000 was for the Drainage Canal proper, $1,556,000 for water-power development, and $7,290,000 for interest.

The ultimate use of the Drainage Canal as a link in an important navigation development from the Great Lakes to the Mississippi River has been contemplated from the start. The report under review states:

> It can hardly be doubted that the canal will eventually form a part of an improved waterway between the Great Lakes and the Mississippi River, though its full depth (22 ft.) will probably not be required for that purpose. Congress has not adopted any scheme for this improvement, but by its direction a survey was made, and plans and estimates for a waterway 14 ft. deep were submitted by a board of engineers in a report dated Aug. 26, 1905. * * * * * The board assumed that the Chicago Drainage Canal would eventually be permitted to take 10,000 cu. ft. per sec. from Lake Michigan, and it expressed the opinion that with that volume added to the natural low water discharge of the Illinois River, a depth of 14 ft. in the open channel could be maintained; also, that if a much greater depth is to be secured, a much larger volume of water must be taken from Lake Michigan.

The water-power works now being constructed by the Sanitary District include an extension of the canal about two miles long, a power-house to accommodate eight 5,000-HP. turbines, and a tail-race 6,800 ft. long. With a head of 34 ft. and with the 14,000 cu. ft. per sec. flow which the Sanitary District wishes to provide, it would be possible to develop about 40,000 E. HP.

The Waterways Commission points out that, with the exception of plans for the enlargement of the Chicago River, none of the plans of the Sanitary District have ever been submitted to any federal authority for approval. It also states that the matter was not laid before any of the federal authorities in any shape until after the canal was opened. On the other hand, the federal authorities have taken no steps to prevent the execution of the plans, and there seems to be "tacit general agreement that Chicago needs, or will need, about 10,000 cu. ft. per sec. for sanitary purposes, and that the city should have it without further question."

Until the Waterways Commission published its report upon Niagara Falls, in March, 1906, it was not "generally known" that the Sanitary District wished to use more than 10,000 cu. ft. per sec. The American and Canadian sections of the Waterways Commission, having in mind merely the preservation of Niagara Falls, recommended that the diversion from Lake Michigan to the Drainage Canal be allowed to that extent (10,000 cu. ft. per sec.). The Commission now states that "the recommendation gave offence to the officials of the Sanitary District, and the further demand then came out in the form of appeals to the committees of Congress and to the Secretary of State." These appeals made it necessary "to take up the question anew, and after considering it in all its bearings, to reach some conclusion as to whether there should be a limit to the amount of water to be diverted at Chicago, and, if so, as to what that limit is."

An elaborate investigation of the effect of the Drainage Canal diversion upon the water levels of Lake Michigan and the waters to which it is tributary has been made under the office of the U. S. Lake Survey in Detroit (see Annual Reports, Chief of Engineers, U. S. A., 1900, p. 5,401; 1902, pp. 2779 and 2825; 1904, p. 4120).

The report of the Waterways Commission may now be quoted at some length, as follows:

> Further observations are needed to be made when the difference of level between Lake Erie and Lake Huron is greater or less than when the existing observations were made, but the results obtained from the latter are believed to be reliable within 0.1 ft. The amounts by which the mean level of the Great Lake system, as derived from observations of the last 46 years of the various waters, will be lowered by a discharge of 10,000 and also by 14,000 cu. ft. per sec. are given in the following table:

Location.	10,000 cu. ft. per sec. ft.	14,000 cu. ft. per sec. ft.
Lakes Huron and Michigan	0.52	0.70
Lake St. Clair	.45	.64
Lake Erie	.45	.64
Lake Ontario	.35	.49
St. Lawrence River at Rapide Plat	.40	.56

From this table it appears that all the waters, including Lakes Michigan and Huron, Lake St. Clair, Lake Erie, Lake Ontario, and the St. Lawrence River, besides the important connecting channels, the Detroit and St. Clair rivers, will be lowered by amounts varying from 4¼ to 6¼ ins. for 10,000 cu. ft., and from 6 to 8½ ins. for 14,000 cu. ft. per sec. The length of time required to produce this effect is about five years; about half of it will be produced at the end of eighteen months. The above figures give the effect at average level; they are much more considerable during low-water periods.

Variations in the level of the lakes' surface, due to winds and to change of barometric pressure, are frequent and irregular and at times violent. Variations of more than 6 ins. are very common, often occurring hourly for many hours in succession, while variations of 2 or 3 ft. within an hour are not uncommon. Besides these irregular variations there is a regular annual variation due to difference in rainfall, evaporation, and run-off, the water level being highest in mid-summer and lowest in mid-winter. The levels are affected also by the greater or less severity of the winter and the consequent greater or less decrease in the discharging capacity of the outlets by ice. In order to study the annual oscillations it is necessary to eliminate the irregular oscillations, and that is accomplished by using the average levels for a month. Using the monthly mean levels it is found that the regular fluctuation in Lake Huron-Michigan usually does not exceed 2 ft. in any one year, but in a long series of years there is a great difference in the height to which high water will rise. The highest water (monthly mean) recorded for that lake was in June, 1886, and the lowest high water in June, 1896, the difference between the two being over 3½ ft. The first is what navigators of the Great Lakes call a high-water year and the second a low-water year.

It is evident that the average level of the lake may be lowered considerably without the change becoming immediately apparent, and that fact has been used as an argument to prove that the lowering caused by the Chicago Drainage Canal is of no consequence to those interested in navigation. Since they can not see it they will not know it and will not feel it. The argument is fallacious. It is true that they can not see it immediately, but they will soon feel it and will know it through the most costly means of acquiring knowledge—the injury to their material interests. The oscillations will remain the same as before, but low water will fall lower and high water will rise less higher. The average draft of vessels must be diminished by the amount that the average level is lowered unless the depth be restored by remedial works.

The most important lake traffic is now carried on in large freight carriers which are loaded down to the greatest draft that can be carried into the harbors or through the channels between the lakes. With the depth now available they are usually loaded to a draft of about 19 ft., but careful watch is kept on the stage of the waterways and advantage is taken of any temporary increase of stage to load the vessels deeper. In the modern vessel each inch of increased draft adds about 100 tons to the carrying capacity. To lower the water surface 6 ins. is to reduce the capacity of the vessel about 600 tons. If the freight rate on iron ore be taken at 55 cts. per ton, exclusive of the cost of loading and unloading, and the number of trips during the season at 22, there appears a loss of over $7,000 for the season for each vessel. The number of vessels navigating the Great Lakes which draw 19 feet or more is 417, and their tonnage is 1,541,414 tons, which is about three-quarters of the total tonnage of the Great Lakes. It is a conservative estimate that the loss to the navigation interests resulting from a reduction of 6 ins. in the depth of water is $2,500,000 per annum, which, capitalized at 4%, amounts to a loss of $62,500,000. With a greater reduction of depth the resulting loss would be proportionately greater. The number of deep-draft vessels and the share of lake traffic which they carry is increasing each year, while the lake traffic itself is increasing with marvelous rapidity. The total number of tons of freight which passed through Detroit River in 1905 was about 58,000,000, valued at about $615,000,000. The records for the year 1906, so far as they are made up, indicate that the number of tons which passed through the Detroit River in 1906 exceeded 65,000,000, valued at $690,000,000. The loss will be even greater in the future than it is now. It is quite certain that the loss will not pass unnoticed, and that the governments will be compelled to restore the depth either by additional excavations or by regulating works.

Careful estimates have been made of the cost of deepening the channels between the lakes 1 ft. To deepen the Detroit River is estimated to cost $4,115,430. In Lake St. Clair the full depth of the lake is now utilized, and any lowering of its surface involves the excavation of an artificial channel entirely across the lake, a distance of 18 miles, of which it has been necessary heretofore to artificially deepen only one-third. To deepen the channel here and at certain shoal places in St. Clair River and at the foot of Lake Huron is estimated to cost $1,080,720. It results in replacing open lake navigation by canal navigation for a distance of 12 miles in Lake St. Clair, a decided disadvantage.

The data are not at hand for an accurate estimate of the cost of restoring the depths in the harbors of the Great Lakes, but an approximation may be reached from a consideration of the cost of improvements heretofore made. The depth to be gained being small, the cost will not vary largely, whether that gain be a few inches more or less. The United States has improved 35 harbors on Lakes Michigan, Huron, and Erie, and has expended thereon about $20,000,000, of which about one-quarter was for maintenance. The average increase of depth is 10 ft., and the cost per foot of increase was therefore about $1,500,000, but as the cost of a small increase would be much greater per foot than an increase of 10 ft., and as several harbors on Lake Ontario are to be added, the cost per foot in this case would probably be not less than $2,000,000 for harbors in the United States. The Canadian Government has improved over 50 harbors on Georgian Bay, Lakes Huron, St. Clair, Erie, and Ontario. A large amount, say $3,000,000, must be added for increasing the depth of these harbors.

The depth in the Welland Canal and in the six canals employed to overcome rapids in the St. Lawrence River is now 14 ft., of which every inch is needed. At the head of the Cornwall Canal in the St. Lawrence River the abstraction of 14,000 cu. ft. of water per second at Chicago will lower the surface about 6¾ ins. at mean level, and much more at low water. To restore the depth in these canals involves the reconstruction of all the end locks and deepening the approaches thereto, and is estimated to cost $2,500,000.

The total cost of restoring the depth in the harbors of the Great Lakes and the channels between the lakes is therefore roughly $10,000,000, and of restoring it in the Welland and St. Lawrence canals is $2,500,000 additional, or $12,500,000 in all.

The shores of the Great Lakes are very far from being fully developed, and it is highly probable that many harbors not now in existence remain to be created, or if in existence remain to be improved. The lowering of the lakes' surface increases the difficulty and cost of such improvements. This consideration is of importance, although no money value can now be given it.

The expenditure of the sums mentioned above will restore the depths now existing, but it will not prevent very serious annoyance to the navigation interests during the execution of the work. The time required will be several years, and in the meantime the vast commerce of the Great Lakes will be hampered, not only by deficient depth, but also by the occupation of the channels, already crowded with commerce, by the excavating machines.

It is evident from the foregoing that large bodies of water can not be diverted by the Chicago Drainage Canal without very serious detriment to the navigation interests of the Great Lakes and of the St. Lawrence Valley. The greater the amount of water diverted the greater the injury. Chicago being one of the principal lake ports, there will be very few communities which will feel this detriment more than she will.

In the presence of these interests the effect upon Niagara Falls may be simply mentioned with a reference to our former reports upon that subject. The volume of Niagara Falls will be reduced by the full amount diverted at Chicago.

The city of Chicago was organized as a city in 1837 with a population of about 4,000. Its population in 1840 was 4,479; in 1850, 28,269; in 1860, 112,172; in 1870, 298,977; in 1880, 503,185; in 1890, 1,099,850, and in 1900 it was 1,698,575. It is estimated now to be about 2,000,000. Should the rate of growth continue which prevailed between 1880 and 1900, the population will be 3,000,000 in the year 1922 and 4,000,000 in the year 1939. It is impossible to foretell its future growth, but there is no reason to doubt that it will in time greatly exceed the largest of these numbers. The city is the commercial center of an empire still in its infancy. It is entirely reasonable to expect a population of five or six millions or more. It will cover territory not now covered. Methods of sewage disposal appropriate to one portion of it may not be appropriate to other portions. If the diversion of 20,000 cu. ft. per min. (or 333⅓ cu. ft. per sec.) for each 100,000 of population, as required by the State law, is accepted as the standard, then from 17,000 to 20,000 cu. ft. per sec. will

be required, and the 14,000 cu. ft. now contemplated will not be sufficient. Even more than 20,000 cu. ft. will be required for a population greater than 6,000,000. The diversion of 20,000 cu. ft. per sec. would lower Lakes Michigan and Huron about 13 ins., and Lake Erie about 11 ins. Plans which lead to this result should be carefully scrutinized.

One of the reasons given in 1889 for adopting this method of disposing of Chicago sewage was that it offered the advantage of furnishing a navigable waterway from Chicago to the Mississippi River. The navigable depth or capacity of such a waterway has never been authoritatively fixed. Congress has considered a depth of 14 ft. to the extent of ordering a survey and estimates of cost for that depth, but the Illinois legislature has declared its policy to be to secure the construction of a deeper channel, not limiting its proposed capacity in terms, but defining it to be "of the greatest practicable depth and usefulness for navigation." (Joint resolutions adopted May 27, 1889.) A fair interpretation of this language gives a proposed depth of 20 ft., that being the depth required to accommodate the most important vessels now navigating the Great Lakes. It will require a volume of water greater than the 10,000 cu. ft. per sec. originally contemplated.

The amount which it is proposed to divert from the Calumet River, 4,000 cu. ft. per sec., is fixed by accident rather than by design, being the excess which the Chicago Drainage Canal is found capable of carrying after providing for the 10,000 cu. ft. from the Chicago River, for which it was originally constructed. It is certain that no greater amount than 4,000 cu. ft. can be diverted from the Calumet without checking the flow from the Chicago River, and thus giving relief to a suburban portion of the city at the expense of the richest and most populous centers.

It is equally certain that the diversion of 4,000 cu. ft. or less will not at all times afford the desired relief to the Calumet. In the first place it provides for a population of only 1,200,000, a number which will in all probability be greatly exceeded at a day not remote. At present the population is estimated at about 200,000, but for the present necessities it is not a question of population, but of drainage area and rainfall. A flood discharge of the Calumet has been measured at Riverdale, about ten miles from its mouth, of about 13,300 cu. ft. per sec. from a drainage area of about 700 sq. m., and even that amount may at times be exceeded. The total drainage area of the Calumet region, including the Sag Valley, is about 825 sq. m., and assuming the discharge to increase in proportion to the area the flood discharge to be provided for is over 15,700 cu. ft. per sec. The diversion of only 4,000 cu. ft. will not prevent a heavy discharge into Lake Michigan in time of flood. To overcome this difficulty it is proposed, if suitable legislation can be secured, to divert the upper Calumet into Lake Michigan through an artificial channel to be excavated in Indiana about 17½ miles east of the State line. Indiana has not authorized such diversion, but supposing it to be accomplished, there will still be times when the discharge from the drainage area remaining to be cared for by the canal, 238 sq. m., will exceed 4,000 cu. ft. per sec. The excess must enter Lake Michigan through the mouth of the Calumet, and at such times the system will fail. Of course it makes no provision for the future occupation of the upper Calumet region and the pollution of the lake from that source. It thus appears that the diversion of the Calumet River as now proposed by the sanitary district will not be complete even for the present, and will not make adequate provision for the future.

The diversion of 4,000 cu. ft. per sec. provides for a population of 1,200,000 by the standard fixed by the State law. The population of the Calumet region is now about 200,000, and until it reaches 1,200,000 only a part of the flow will be needed for sanitary purposes during a large part of the year; but the channel must be there, available for the full flow, if this method of sewage disposal is to be useful to any population, however small. Likewise the channel from the Chicago River must be, as it is, large enough to provide for a population of 3,000,000, whether that number of people are ever to become tributary to the Chicago River or not. The channels having once been constructed, any reduction of flow below their fullest capacity is a dead loss to the water power dependent upon them. It has been said that it would be absurd to develop water power at the cost per horse-power which this water power costs if the drainage canal be included, and that is true. But being given the channels, it would not be absurd to use them to their fullest capacity. The Chicago Drainage Canal having been constructed with a capacity, as it turns out, of 14,000 cu. ft. per sec., full power development will call for the whole of that amount, and in fact power works are now under construction at Lockport to utilize it. Inasmuch as the santitary requirements by the standard fixed in the State law are only 6,667 cu. ft. per sec. for the present population of 2,000,000, it is evident that power development, incidental though it be, does lead to demands for water not required for sanitary purposes.

It remains to be seen whether any diversion, complete or otherwise, is necessary to preserve the health of Chicago. Upon this point the commission sought the advice of two eminent sanitary engineers—Messrs. Rudolph Hering and George W. Fuller—whom it instructed as follows, viz:

> To examine the sanitary situation at Chicago, so far as it is affected by sewage disposal, and to report whether it is or is not necessary to the health of the city to extend to outlying territory the system which was adopted in 1889 for the main city. * * * The commission desires an emphatic opinion from authoritative sources as to whether the system of diverting the water of Lake Michigan in large quantities into the Illinois Valley is the only way to preserve the lives and health of the people of Chicago. It does not desire an investigation of the effect upon the navigation interests of the Great Lakes. It has satisfied itself upon that point. Nor does it wish to reopen the case of the Chicago Drainage Canal as designed and built. It accepts that as a fixed fact, with its attendant diversion of 10,000 cu. ft. per sec. through the Chicago River. The extension of the system to the Calumet River alone is in question, and the question is, Are there not other methods of sewage disposal which can be applied here at a cost not exceeding much, if at all, the cost of the method proposed, and which will be equally effective in preventing the pollution of the lake? It desires a report upon the various systems which may be found available for application here, with a statement of their relative efficiency. It also desires a statement of their relative cost, so far as that can be given without the preparation of detailed plans. The latest conclusions of sanitary engineers as to the amount of dilution which is required to make sewage inoffensive should be given.

These gentlemen visited Chicago, and after a thorough examination of the situation submitted a report, of which a copy is hereto appended. The entire report should be carefully studied.

The conclusions of the report of Messrs. Hering and Fuller are included in an abstract of the report, printed in the article which follows, and therefore need not be repeated here. It may be added that Mr. Hering

was Chairman of the Commission of 1887, whose report to the Mayor and City Council of Chicago was the foundation of the subsequent legislation, and led to the construction of the Drainage Canal. The conclusions reached are those of friends of Chicago, and not of her enemies or rivals.

The Waterways Commission, at the close of its report, presents a summary of the facts already presented, and closes with certain recommendations. In view of our preceding condensation of the report, it seems unnecessary to present the summary, except the last three paragraphs. These, together with the recommendations, are as follows:

> The extension to the Calumet region of the method of sewage disposal already applied to the Chicago River is not necessary to preserve the health of Chicago, there being other and better methods available for the Calumet region. The final cost of these methods is somewhat greater than that of the one proposed, but the works can be developed as the population increases, and only a part of their cost need be incurred at present, while their greater efficiency justifies the increase of final cost.
>
> The diversion of 10,000 cu. ft. of water per sec. at Chicago will render practicable a waterway to the Mississippi River 14 ft. deep. Any greater depth must be obtained by the abstraction of more water from Lake Michigan and at the expense of the navigation interests of the Great Lakes and of the St. Lawrence Valley.
>
> The effect upon Niagara Falls of diverting water at Chicago is of secondary importance when considering the health of a great city and the navigation interests of the Great Lakes and of the St. Lawrence Valley, but it is proper to note that the volume of the falls will be diminished by the full amount diverted at Chicago.
>
> RECOMMENDATIONS.
>
> The waters of Lake Michigan in the United States, the waters of Georgian Bay in Canada, and the waters of Lake Superior partly in the United States and partly in Canada all form sources of supply of the Great Lakes system, finding their way by the St. Lawrence to the sea. All are interdependent and there can be no diversion from any of them without injury to the whole system. By Article XXVI. of the treaty of 1871 it is provided that
>
> navigation of the River St. Lawrence, ascending and descending from the forty-fifth parallel of north latitude, where it ceases to form the boundary between the two countries, from, to, and into the sea, shall forever remain free and open for the purposes of commerce to the citizens of the United States, subject to any laws and regulations of Great Britain, or of the Dominion of Canada, not inconsistent with such privileges of free navigation.
>
> It is desirable that in any treaty arrangement the waters of Lake Michigan, Georgian Bay, and all other waters forming part of the Great Lakes system should be declared to be "forever free and open for the purposes of commerce" to the citizens of the United States and the subjects of His Britannic Majesty, subject to any laws and regulations of either country not inconsistent such privilege of free navigation.
>
> The preservation of the levels of the Great Lak imperative. The interest of navigation in these wat paramount, subject only to the right of use for dom purposes, in which term is included necessary sani purposes. In our report of Nov. 15, 1906, upon the a cation of the Minnesota Canal & Power Co. to d certain waters in Minnesota we recommended, an other things,
>
> that any treaty which may be entered into should de the uses to which international waters may be put either country without the necessity of adjustment each instance, and would respectfully suggest that s uses should be declared to be (a) uses for necessary mestic and sanitary purposes; (b) service of locks navigation purposes; (c) the right to navigate.
>
> It is our opinion that so far as international action concerned a treaty provision of that kind is all that required in this case. We accordingly renew our recom mendation of Nov. 15, 1906, just quoted.
>
> A careful consideration of all the circumstances lea us to the conclusion that the diversion of 10,000 cu. per sec. through the Chicago River will, with prop treatment of the sewage from areas now sparsely oc pied, provide for all the population which will ever tributary to that river, and that the amount named w therefore suffice for the sanitary purposes of the ci for all time. Incidentally it will provide for the large navigable waterway from Lake Michigan to the Missi sippi River which has been considered by Congress.
>
> We therefore recommend that the Government of th United States prohibit the diversion of more than 10,0 cu. ft. per sec. for the Chicago Drainage Canal.

REPORT ON THE TREATMENT OF PART OF THE SEWAGE OF CHICAGO AND ITS RELATION TO THE CHICAGO DRAINAGE CANAL.

Doubtless many of our readers will be surprised to know that even the possibility of establishing sewage treatment works for a considerable portion of the city of Chicago has been taken under consideration, but such is the case. The matter, however, has not been brought up by either the city or the trustees of the Chicago Sanitary District (at least not directly), but by the International Waterways Commission. The reasons for considering this subject are set forth in the abstract on preceding pages of a report on the Chicago Drainage Canal just issued by the commission named. The engineering questions involved in the disposal of the sewage of the Calumet District of the city, without diverting it to and through the Drainage Canal, were referred by the commission to Messrs. Rudolph Hering and George W. Fuller, of New York City.

In opening their report, which is dated Dec. 18, 1906, Messrs. Hering and Fuller call attention to the fact that they were requested to deal merely with the sewage disposal aspect of the question, without regard to navigation interests or legal or legislative questions. Some of the data given in this portion of the report have already been presented in the other article in this issue, already mentioned. A large part of the work of reversing the flow of outlet sewers so they will discharge into the Drainage Canal instead of into the lake has already been accomplished and within a comparatively short time this work will be largely completed.

The present population of Chicago, in round numbers, is 2,000,000, and of this it appears that the sewage of about 1,500,000 people is being discharged into the Drainage Canal. In addition, large quantities of trade waste are going the same way, but it is understood that ultimately trade wastes will be disposed of in some other way.

The water supply of Chicago is taken from Lake Michigan through tunnels extending 1 to 5 miles from the shore, and mostly reaching some 2 miles into the lake. The total waterworks pumping capacity is reported as 529,000,000 gals. per 24 hours, and the average daily pumpage in 1905 as 399,000,000 gals. The operation of the Drainage Canal has greatly benefited the appearance of the Chicago River, and appears to have materially improved the sanitary quality of the public water supply. The typhoid fever death rates per 100,000 in Chicago were 83 in 1890, 160 in 1891 and 103 in 1892. In 1893 the rate fell to 42, and in general it fell after that date (due in part to water intake tunnel

extensions), reaching 26 in 1899. In 1900, the first year of operation of the Drainage Canal, it decreased to 20, but in 1901 it reached 29 and in 1902, 44. The high rates in 1902 were attributed to the contamination of a portion of the supply after the water left the intake cribs. In 1904 the typhoid death rate per 100,000 was 19, and in 1905 it fell to 16.

As to the minimum dilution of sewage required to prevent nuisance, Messrs. Hering and Fuller state that

> the large canals with the trade wastes eliminated, a dilution of 3½ cu. ft. per sec. for each 1,000 population connected with the sewers also receiving storm water, is as low a figure as it is now possible to state. Local conditions, especially temperature, which affects bacterial activities and the coefficient of absorption of oxygen by water, and still other matters, bear upon the question, the detailed discussion of which is not now necessary. We feel certain that a dilution of 2½ cu. ft. per sec. would cause offence at times, and probably also a dilution of 3 cu. ft. per sec.

On the basis of the flow of Lake Michigan water of 3 1-3 ft. per sec. for each 100,000 of population, and with 10,000 cu. ft. per sec. of water flowing through the Drainage Canal, the latter would serve 3,000,000 people; or with a total flow of 14,000 cu. ft., 4,200,000 people. It is reasonable to assume that the population of Chicago "before many years" will reach five or six million, or, in other words, the present dilution method will eventually become insufficient for the treatment of the sewage of the whole city. It is not considered probable that the sewage from the older part of Chicago will ever be treated by artificial means, owing to the various difficulties involved, but it is likely that sewage purification works will be necessary ultimately for outlying districts where land for the purpose can be more readily secured.

On the subject of the proposed Calumet Canal, and the relation between sewage disposal for the Calumet area and the water supply of Chicago, and available methods of sewage treatment for the Calumet area, the report may be quoted as follows:

PROPOSED CALUMET CANAL.

The more essential features of this proposed canal, as obtained from local officials, may be summarized as follows:

LOCATION.—The canal would extend from a point on the Little Calumet River near Blue Island, through the Sag Valley, and enter the drainage canal near Sag Station.

TERRITORY TRIBUTARY.—The total drainage area of the Calumet River is 825 sq. mi., of which 473 are in Indiana. Within the limits of the sanitary district of Chicago and south of 87th St., the area is 94.5 sq. mi., with a population of about 100,000 in 1900. It is stated that the population has nearly doubled within the past six years, and it is expected to reach a million people or more within a fairly short period, as the conditions for a manufacturing district are very favorable.

SIZE.—The size of this canal, as proposed, is such as to give a flow of 4,000 cu. ft. per sec.

REVERSAL OF FLOW.—The natural flow of the Calumet River exceeds 12,500 cu. ft. per sec. It is proposed, if suitable legislation can be secured, to construct a dam below Thorn Creek, at the southern boundary of the sanitary district, and divert into Lake Michigan, through a channel to be built about 17½ miles east of the State line, the flow of this stream, with a drainage area of about 587 sq. mi. The size of the proposed Calumet Canal is too small to secure at all times a reversal of flow of the remaining portion of the area, which is about 240 sq. mi. It is proposed to put a controlling lock on the canal east of Blue Island to prevent flood waters from this lower area entering the canal, at which times sewage entering the river on the lake side of the lock would go into the lake.

The proposed canal is insufficient to carry in the future all the storm flows of the Sag Valley itself. These would, at least in part, require diversion through present or other channels.

COST.—The estimated cost of this proposed canal is $12,000,000.

POPULATION TO BE SERVED.—On the assumption already stated, this canal, by dilution, would dispose of the sewage of about 1,200,000 people, not including objectionable trade wastes. This makes the cost of sewage disposal $10 per capita for the entire future population, or about $60 for the present population. The sewage would for the most part reach the canal by gravity through the Calumet River, so that the cost of maintenance would be comparatively small.

In passing, we may say that the Calumet area, both in Illinois and Indiana, is certain to develop rapidly, and its population will eventually far exceed the above figure.

RELATION OF SEWAGE DISPOSAL FOR THE CALUMET AREA TO THE WATER SUPPLY OF CHICAGO.

For the reasons above stated in connection with the reversal of flow, the sanitary effect upon Lake Michigan water at the Hyde Park intake and vicinity of this proposed Calumet Canal would not be nearly as effective as that of the main canal for the Chicago River territory and neighboring intakes. This fact is important in connection with the degree of sewage purification required by artificial purification works to give a sanitary effect equal to that of the proposed canal.

There seems to be no doubt that at times the sewage entering the Calumet River under present conditions from this district pollutes the lake water from the Hyde Park intake crib. It may pollute the water at other intakes, but our evidence is not conclusive. In the future, when the Calumet area is built up, it is possible that intake cribs may be built nearer to the mouth of the Calumet River than is the Hyde Park intake.

In view of the fact that the proposed Calumet Canal can not keep all sewage out of Lake Michigan at times of heavy rainfall, it is important to note that the water supply of this section of Chicago will eventually have to be purified by modern filtration works. This can be done at moderate cost, and it will be the cheapest and best solution of this problem to filter the water supply of this district and to purify the sewage to such a degree that the effluent will be fairly clear and nonputrescible, that is, free from disagreeable odors. With additional expense the sewage effluent (of the quality just stated) can be given a supplementary purification, making it practically free of bacteria by treating it with a germicide or by filtering it according to water-purification practice.

Under existing conditions we are firmly of the opinion that all the purification required of the sewage of the Calumet District is to make it fairly clear and nonputrescible.

AVAILABLE METHODS OF SEWAGE DISPOSAL OTHER THAN THAT OF THE DILUTION METHOD PROPOSED FOR THE CALUMET AREA.

The degree of purification of sewage by various forms of treatment differs naturally under different local conditions, but from general experience approximate results may be compared, substantially as follows:

Method.	Percentage purification. Suspended matter.	Organic matter.	Bacteria.
Fine screens (30-mesh or finer)	15	10	15
Sedimentation	65	30	65
Septic treatment	65	30	65
Chemical precipitation	85	50	85
Contact filters*	85-90	65-70	80-85
Sprinkling filters*	85-90	65-70	90-95
Intermittent sand filters*	95-99	90-98	98-99

*The figures for the last three forms of treatment are on the assumption that the sewage is given some form of preparatory treatment before it is applied to the filters, and that with the sprinkling filters the effluent is allowed to settle.

It is to be stated that none of the first four treatments above tabulated will by itself give a nonputrescible effluent. Therefore they can be used here only in connection with some form of filtration.

For large works filters can be more economically operated if the sewage is first clarified in part, as stated in connection with the above summary. The most appropriate method for this preparatory or preliminary treatment is considered by most sanitary engineers in this country and abroad to consist of septic tanks, which is the expression applied to sedimentation basins in which the deposited sludge is allowed to accumulate to undergo bacterial action.

There are several forms of filters, the most widely known of which, in this country, is the intermittent sand filter, sometimes mentioned as the so-called "land treatment" for sewage disposal. This method was considered in 1886-87 for the entire Chicago area and reported upon unfavorably on account of its being more expensive than the adopted method of dilution.

LOCAL EXPERIENCES.—We find that a feeling appears to prevail among some persons at Chicago against land treatment of sewage, due perhaps to the unsuccessful operation of the sewage farm at Pullman, which is situated within this Calumet area.

We are familiar with the facts and experiences at Pullman, and are clearly of the opinion that they are not necessarily a criterion for the Calumet area. This opinion is based partly upon the small size of particles of the soil at the Pullman farm, and partly upon the fact that the farm was devoted principally to agricultural rather than sewage-purification purposes.

SAND AREAS.—We have examined the tracts of lake sand which are found in Indiana and to a limited extent in the township of Thornton, Ill. The latter areas are too limited in extent and too shallow to be considered for present purposes. The only areas of suitable porous sand for land treatment of the Calumet sewage are in Indiana.

We have collected five samples of this sand for mechanical analysis, and have obtained the results as to size of sand grains. Representative results average substantially as follows: Effective size, 0.15 mm.; uniformity coefficient, 1.4 mm.

If we disregard the State boundary line, a large tract of sand of a suitable character is available for the disposal of the sewage of this district. The best area lies between the Little Calumet and the Grand Calumet rivers, and extends east of Hammond for many miles.

Some of the features common to any method of sewage treatment for the Calumet area are outlined as follows: It is considered advisable to build a separate sewerage system for domestic sewage only, and to exclude all trade wastes from such sewers. In the estimates, nothing has been allowed for a separating system nor for delivering the sewage into necessary intercepting sewers. The volume of sewage to be treated is based on a daily average of 130 gals. per capita, or 156,000,000 gals. for a total population of 1,200,000 people. An allowance has also been made for ground-water seepage, up to 1,000 gals. per sq. mi. per day. Concrete intercepting sewers, with a capacity of 250 gals. per 24 hours and flowing full with a velocity of 2½ ft. per sec., have been allowed for. It has also been estimated that the population per acre would be 20 to 25 persons. Four main pumping stations, with a total daily capacity of 340,000,000 gals., have been assumed. Allowance has also been made for concrete septic tanks 12 to 15 ft. deep, "arranged in compartments so as to facilitate septic action." On account of low winter temperatures at Chicago, it is considered advisable to cover the tank. It is estimated that 65% of the solid matters in suspension in sewage would be deposited in the septic tanks, and that of the matter so deposited half would be liquefied and gasified. Sludge disposal by spreading over land is contemplated.

After outlining the foregoing features common to any method of final treatment likely to be adopted, the authors of the report take up in succession intermittent sand, contact and sprinkling filters.

INTERMITTENT SAND FILTERS.—With preliminary treatment in septic tanks it is assumed that sand filters "operated under intelligent supervision" would give satisfactory results on the basis of 1 acre per 1,000 persons. While possible to build such filters within the Calumet District itself, "the cost would be much greater than for any of the projects considered in this report." The estimated cost of the sand filter plant and appurtenances is as follows:

CONSTRUCTION.

Intercepting sewers, pumping stations, and appurtenances, including a daily capacity of 340,000,000 gals., and rising mains	$5,070,000
Septic tanks, 60,000,000 gals. capacity, covered, including sludge-disposal facilities	950,000
Filters, 1,200 acres, with office, laboratory, etc.	3,600,000
	$9,620,000
Contingencies and supervision, 15%	1,443,000
Total	$11,063,000

OPERATION.

Pumping, fuel, labor, and repairs	$300,000
Supervision, analytical and clerical assistance, etc.	25,000
Care of septic tanks, including sludge disposal	36,000
Care of sand filters	480,000
Supplies and miscellaneous	25,000
Total	$866,000

On a 5% capitalization basis, the operating expenses would be $17,320,000, making, with the construction cost, a total of $28,383,000.

CONTACT FILTERS.—Available sites for these were found west of Harvey, between the Illinois Central and Rock Island Railroads; west of Hammond and the local branch of the Fort Wayne R. R.; and between Lakes Calumet and Wolf. It was assumed that contact filters 5 ft. in depth would give a satisfactory effluent at a rate of 600,000 gals. per acre per 24 hours, or that 1 acre would serve 4,000 persons. The effluent "would be ordinarily free from objectionable amounts of suspended matter, and the amount of organic matter would be so reduced that it would not putrefy upon standing." Some 15 to 20% of the applied bacteria would remain in the effluent. The effluent could be discharged directly into the nearest water course. All the material (probably somewhere from ¼ to 1 in. in diameter) in the contact bed would have to be removed, washed and replaced at intervals. The estimated cost of contact beds, for the same

quantity and population as was stated for intermittent filtration, would be as follows:

CONSTRUCTION.	
Intercepting sewers, pumping stations, and appurtenances, including a daily capacity of 340,000,000 gals., and rising mains.....	$3,300,000
Septic tanks, 60,000,000 gals. capacity, covered, including sludge-disposal facilities...	950,000
Contact filters, 300 acres, office, laboratory, etc.	6,000,000
	$10,250,000
Contingencies and supervision, 15%.....	1,537,500
Total	$11,787,500
OPERATION.	
Pumping, fuel, labor and repairs.....	$200,000
Supervision, analytical and clerical assistance.	30,000
Care of septic tanks, including sludge disposal	36,000
Care of contact filters	260,000
Supplies and miscellaneous	25,000
Total	$551,000

The operating expenses, capitalized at 5%, amount to $11,020,000; and this, added to the construction cost, makes a total of $22,807,500 for contact filters.

SPRINKLING FILTERS.—Fixed sprinklers 12 to 15 ft. apart are considered, with broken stone from 1 to 2½ ins. mean diameter with a depth of about 7 ft. as material for beds. The estimates are based on the same sites as were considered for contact beds. It is thought that the low temperatures of Chicago would not cause difficulty with the sprinkling filters if the sewage was applied under a head of 6 or 7 ft., but owing to possible accumulation of frozen sewage on the filters during zero weather reserve areas would be necessary. It was accordingly assumed that 1 acre of beds would serve 15,000 people, making a rate of about 2,250,000 gals. per acre per 24 hours. The results obtained at the sewage testing station at Columbus, O., showed that this rate could be doubled several weeks at a time and still give satisfactory non-putrescible effluents. Expressed in population per acre-foot of filter material, the rate is about one-half that provided for in the works now under construction at Columbus, and one-third that actually employed in a number of British works. To remove the suspended matter in effluents from filters of this type two hours' sedimentation is proposed, which, it is thought, would give a final effluent of satisfactory appearance, non-putrescible, and usually containing not more than 10% of the bacteria in crude sewage. The estimated cost of sprinkling filters, of the same capacity as proposed for intermittent and contact filters, is as follows:

CONSTRUCTION.	
Intercepting sewers, pumping stations, and appurtenances, including a daily capacity of 340,000,000 gals., and rising mains.....	$3,300 000
Septic tanks, 60,000,000 gals. capacity, covered, including sludge-disposal facilities....	950,000
Sprinkling filters, 80 acres, office, laboratory, etc.	3,600,000
Settling basins, 15,000,000 gals. capacity.....	200,000
	$8,050 000
Contingencies and supervision, 15%.....	$1,207,500
Total	$9,257,500
OPERATION.	
Pumping, fuel, labor and repairs.....	$200,000
Supervision, analytical and clerical assistance.	30,000
Care of septic and settling tanks, including sludge disposal	54 000
Care of sprinkling filters	110 000
Supplies and miscellaneous	25 000
Total	$419,000

The operating expenses, capitalized at 5%, amount to $8,380,000, which, with the cost of construction, would make the total estimated cost of sprinkling filters $17,637,500.

A comparison of the three methods, after adding together construction costs and the capitalized amount of the operating charges, shows that intermittent sand filters would aggregate $28,383,000; contact filters, $22,807,500; sprinkling filters, $17,637,500. The latter method of treatment is "clearly the most advantageous one."

VOTING MACHINES are increasing in popularity. A circular issued by the U. S. Standard Voting Machine Co., of Rochester, N. Y., shows that while only six of its machines were in use in 1897, there were 2,431 machines in use in 1906, and they are used in the states of New York, New Jersey, California, Indiana, Wisconsin, Nebraska, Iowa, Utah, Connecticut, Michigan and Ohio.

REPORT ON FAILURE OF REINFORCED CONCRETE BUILDING OF EASTMAN KODAK CO., KODAK PARK, N. Y.

Since the unfortunate accident* at the works of the Eastman Kodak Co., Kodak Park, near Rochester, N. Y., when a portion of a reinforced-concrete building collapsed during construction, the owners have engaged two consulting engineers experienced in concrete work to make an investigation of the remaining part of the structure. The investigation included a study of the failure and tests of portions immediately adjacent to the area of collapse. This first part of the investigation has been concluded, and under date of Dec. 31, 1906, a report was made to the owners which, through the courtesy of Mr. F. W. Lovejoy, of the Eastman Kodak Co., we are enabled to reproduce here. Mr. Edwin Thacher, of New York, and Prof. C. W. Marx, of Cincinnati, O., are the experts engaged to make the study in question. Their preliminary report is as follows:

As per your request, we have examined the concrete-steel-tile construction in your Emulsion Building, especially that portion tributary to Column 47, and beg leave to make the following report as to the cause of the collapse:

We are fully convinced that the primary cause of the failure was due to the fact that the supports under girders and floor construction were removed too soon for that season of the year, your records showing that the concrete was only about three weeks old. The concrete throughout is of good quality, but was too green (i. e., not sufficiently hard) to enable the respective members to carry even their respective dead loads with safety. Had the forms around the columns and sides of the large beams been first removed, and the supports under girders and floor construction left undisturbed for a period of at least four weeks longer, it is our opinion that you would not have experienced the slightest trouble.

We do not find that any abnormal or eccentric loading exists.

Cross sectional area of Col. 47 =.....	144	sq. ins.
Steel area = ...	2.24	
Net concrete area = ...	141.76	sq. ins.
15 times steel area = ...	33.6	
Total effective area reduced to concrete =	175.36	sq. ins.

The unit dead-load stress on Col. 47 = 61,300 ÷ 175 = 350 lbs. per sq. in.

The unit dead and live-load stress on Col. 47 = 107,000 ÷ 175 = 612 lbs. per sq. in.

It is customary to reduce the live load as it comes on to the girder and column, for the reason that owing to the necessity of passageways only 80% of the floor can be loaded; therefore using 80% of the live load on mezzanine floor, the total unit stress per square inch of Column 47 equals 103,000 ÷ 175 = 594 lbs. per. sq. in.

In our calculations we used an ultimate compressive stress on concrete (mixed as in your building) of 3,000 lbs. per sq. in. Using a factor of safety of 4 will give 750 lbs. per sq. in. as a safe working stress. On steel as used in your building we allowed an ultimate tensile stress of 64,000 lbs. per sq. in., which, with a factor of safety of 4, will admit of a safe working stress of 16,000 lbs. per sq. in.

We further submit the following detailed report of actual test conducted on Col. 43. Col. 43 is constructed the same as was Col. 47.

The marked prints herewith [not reproduced.—Ed.] show areas of roof and mezzanine floor that were loaded with tile. The red tile were 12 × 12 × 4 ins. and weighed 21 lbs. apiece; the yellow tile were 12 × 12 × 4 ins. and weighed 17.75 lbs. apiece. Owing to the fact that the area tributary to Col. 43 is smaller than the area tributary to Col. 47, increased unit live loads were used in order to produce an excess column load.

The area marked is 40 × 31 ft., which equals 1,240 sq. ft.; the total weight of tile on this area uniformly distributed equals 80,000 lbs. The weight per square foot of loaded area equals 80,000 ÷ 1,240 = 64.5 lbs. The additional central load placed directly over the column occupied a space of 10 × 10 ft. and weighed 21,200 lbs.

Total dead load of roof supported by Col. 43 =	41,250 lbs.
Total live load of roof supported by Col. 43 =	42,980
Total dead and live load of roof including column and girders supported by Col. 43 =..	84,230 lbs.

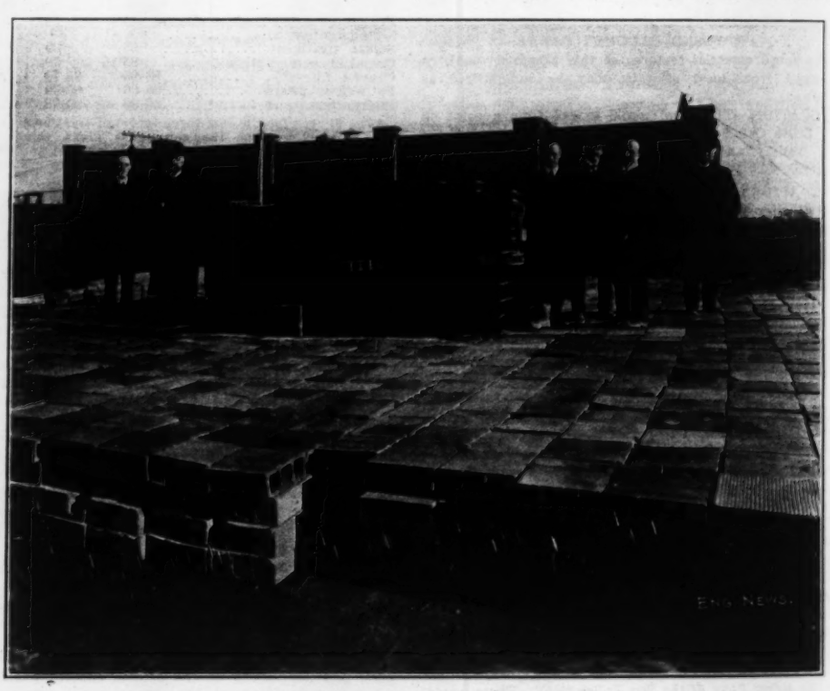

FIG. 1. LOAD TEST OF ROOF NEAR COLLAPSED PORTION; EMULSION BUILDING OF EASTMAN KODAK CO., KODAK PARK, N. Y.

The girders tributary to Col. 47 were constructed and executed with ample factor of safety. We find that

The dead load of roof construction coming on Col. 47 = ...	45,000 lbs.	
The dead load from mezzanine floor construction = ...	16,300	
Making the total dead load of roof and mezzanine floor construction (together with the weight of column) on Col. 47 = ...		61,300 lbs.
Live load from roof =.....	29,700 lbs.	
Live load from mezzanine floor =	16,000	45,700 lbs.
Combined dead and live load on Col. 47 = ...		107,000 lbs.

*A full account is given in Engineering News, Jan. 3, 1907, pp. 1-5.

The mezzanine floor was loaded with five courses of red tile and one course of yellow tile, total weight per sq. ft. equals 122.75; allowing 5% for unloaded areas will give a uniform load of 122.75 ÷ 105 = 117 lbs. per sq. ft. The area of mezzanine floor supported by Col. 43 is 163 sq. ft.

Mezzanine floor live load = 163 × 117 =....	19,100 lbs.
Mezzanine floor dead load = 163 × 83 =....	13,500
Girders A and C =.....	1,905
Col. 43, mezzanine floor to floor below, 8.5 × 114 = ...	1,220
Total dead and live load from mezzanine floor transmitted to Col. 43 =.....	35,725 lbs.
Total dead and live load from roof transmitted to Col. 43 = ...	84,230

Combined dead and live loads from roof and mezzanine floor transmitted to Col. 43 = 119,955 lbs.

Estimated combined dead and live loads from mezzanine floor and roof transmitted to Col. 43 = ... 107,000 lbs.

$\frac{119,955}{107,000}$ = 112%, or the test load was 12% greater than the load for which the column was designed. This gives a unit stress of $\frac{119,955}{175}$ = 687 lbs. per sq. in.

a piece of floor as wide as three *complete* floor-beam spacings, or 48 ins. and 51 ins., respectively. The tests were reported as follows:

TEST ON ROOF SLAB.—A section of the roof between Cols. 45-43 and 51-53 was tested as follows:

In a perfect section a portion consisting of three joists and two tile was isolated by breaking out the tile and concrete next to the two outside joists. The cinder filling and cement finish were removed; 4 × 4-in. props and ledgers with suitable cross diagonals in both direc-

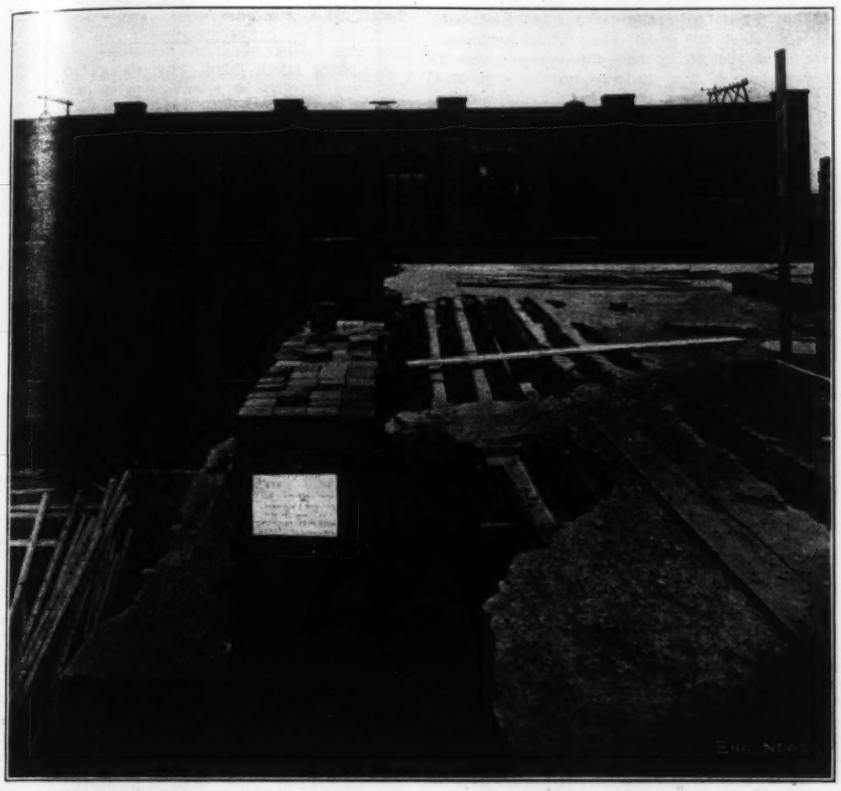

FIG. 2. LOAD TEST OF ISOLATED SECTION OF MEZZANINE FLOOR SLAB; EMULSION BUILDING OF EASTMAN KODAK CO., KODAK PARK, N. Y.

As before stated, it was found necessary to increase the unit live loads; this gave a unit load on roof of 64.5 lbs., or $\frac{14.5}{50}$ = 29% more than specified. The live load on mezzanine floor was 117 lbs. per sq. ft., or 17% more than specified.

The deflection under the mezzanine floor load with 117 lbs. per sq. ft. was $\frac{3}{16}$-in. The deflection of the roof was $\frac{3}{32}$-in. in middle of 21-ft. and 19-ft. spans. These deflections are very small considering the loads.

Yours truly,

(Signed) Edwin Thacher.

(Signed) C. W. Marx.

Rochester, N. Y., Dec. 31, 1903.

After these tests had been reported, the owners conducted a further test, by their own engineers, to throw more direct light on the carrying capacity of the floor construction. We may recall that the floors in this building are combination tile and reinforced concrete, comprising floorbeams of reinforced concrete on full panel spans between girders, alternating with single rows of hollow tile. The tile are 12 ins. wide, and the beams 4 and 5 ins., so that the beams are spaced 16 ins. c. to c. in the roof and 17 ins. in the mezzanine. A 2-in. layer of concrete over the tops of the tile forms the carrying structure between beams, as the tile are considered as filling merely. This 2-in. layer is sometimes also calculated as part of the compression flange of the beams, and we understand it was so figured in the present structure. The additional tests were made on strips of floor comprising three of the reinforced concrete beams with the two intervening rows of tile, isolated by cutting two slots longitudinally through the 2-in. top layer about 36 ins. apart in the case of the roof and 48 ins. apart in the case of the mezzanine. The strength of such a section evidently corresponds to the strength of

tions were put under the section to be tested, leaving a clear gap of about 6 ins. between the bottom of the slab and the top ledgers, this structure being placed to catch the slab and load if failure occurred.

The load consisted of 4 × 12 × 12 in. yellow tile laid flat three wide and seventeen long, the area covered by them being 19 ft. by 3 ft., or 57 sq. ft. The tile were piled 19 courses high. The actual number of tile = 19 × 17 × 3 = 969; by 17 lbs. equals 16,473 lbs. (considering the tile to weigh 17 lbs. apiece).

The unit load was 16,473 ÷ 57 = 289 lbs. per. sq. ft. The deflection under this load was ¼-in. The span from center to center of beams was 19 ft., and the clear span of the slab 18 ft. 2 in. The width of section tested was 3 ft. (three 4-in. joists equals 12 ins., two 12-in. tile equals 24 ins).

The load was then increased until the tile were 25 courses high; the number of tile was 25 × 17 × 3 = 1,275, and their weight 1,275 × 17 = 21,675 lbs.

The unit load = $\frac{21,675}{57}$ = 380 lbs. per sq. ft. (with tile at 17 lbs.). The deflection under this load was ⅜-in. When this load was removed the deflection was reduced or went back until it was only $\frac{1}{16}$-in.

Actually weighing the tile gives the following result: The weight of tile = 21,875; the unit load = 21,875 ÷ 57 = 384 lbs. per sq. ft., and the weight per tile 21,875 ÷ 1,275 = 17.2 lbs. each.

The roof slab weighs 58 lbs. per sq. ft. and consists of 6-in. tile with 2-in. concrete, the reinforcement being ½ × 1½-in. Kahn bars spaced 16 ins. on centers.

384 live load
58 dead load

442 dead and live load.

$\frac{384}{50}$ = 7.7 times the live load designed for

58 dead load
50 live load

108 lbs. dead and live load.

$\frac{442}{108}$ = 4.09 times the dead and live load designed for.

TEST ON MEZZANINE FLOOR.—A section between mezzanine beams A and D, Columns 37-38 and 45-46, was cut out and prepared as described in the roof test. The isolated section consisted of 3 joists and 2 tile. On this, 4 × 12 × 12 in. tile were piled 4 wide, 17 long and 19 high and a photograph taken. The number of tile = 19 × 17 × 4 = 1,292. Considering these tile to weigh 21 lbs. apiece, their total weight = 1,292 × 21 = 21,132 lbs. The actual area covered by the tile was 20 ft. by 4 ft., or 80 sq. ft., and the unit load therefore was $\frac{27,132}{80}$ = 340 lbs. per sq. ft. This is the load shown in the photograph. [Fig. 2.—Ed.] The photograph gives this load as 350 lbs. The above weights are estimated.

Actually weighing the tile gives the following results: Weight of the tile = 30,675 ÷ 80 = 384 lbs. per sq. ft. actual weight.

The deflection was ½-in. On removing the load the deflection returned to ⅛-in.

The mezzanine floor slab consists of 10-in. tile and 2-in. concrete with ¾ × 2-in. Kahn bars 17 ins. on centers; weight per sq. ft. 85 lbs.

Live load ..... 384 lbs.
Dead load 85

469 lbs.

Designed for
Live load ..... 100 lbs.
Dead load 85

Dead and live loads 185 lbs.

$\frac{469}{185}$ equals 2.54 times the dead and live loads.

$\frac{384}{100}$ equals 3.84 times the live load.

(Signed) F. A. Cole,
(Signed) John F. Ancona,
Engineers employed at Kodak Park.

Jan. 3, 1907.

Attention is directed to the fact above noted that in the test on the roof slab, the strip isolated included 3 beams, being 36 ins. wide but really corresponding to 48 ins. (3x16 ins.) width of floor, while the computations of load per sq. ft. are based on the 36-in. width. If the width of 48 ins. be used, the superimposed test load gives a unit load of 216 lbs. (instead of 289 lbs.) in the first stage of the test, and 286 lbs. (instead of 384 lbs.) in the second stage of the test. The final loading, dead and live, is then 286 + 58 = 344 lbs. per sq. ft., which is 344 ÷ 108 = 3.2 times the total load designed for. Of course, some allowance may be required for injury to the floor along the edges where the concrete was cut through, and for the absence of a 6-in. strip of the 2-in. concrete surfacing along each edge, which strip would probably add a slight element of strength.

In the computation for the mezzanine floor slab a similar but smaller effect of this kind occurs. The joists appear to have been spaced 17 ins. c. to c., so that three joists would correspond to 51 ins. width of floor. The unit load appears computed for a width of 4 ft. (although the strip comprising three joists and two tile is only 38 ins. wide). Using 4¼ ft. width in place of 4 ft., the load superimposed in this test gives a unit load of 30,675 ÷ 85 = 361 lbs. per sq. ft. (instead of 384 lbs.). The total load, then, was 361 + 85 = 446 lbs. per sq. ft., so that the ratio of total load in the test to the total load designed for is 446 ÷ 185 = 2.41 (instead of 2.54).

THE CHICAGO DRAINAGE CANAL was required by law to be opened for navigation within seven years after water had been let into the canal. This time limit expired in January, 1907, but the canal is not yet navigable as the drawbridges which cross it have not been fitted with operating machinery. When the bridges were built it was considered advisable not to incur the expense of the operating machinery, which would be idle for several years, but no steps have been taken to instal this machinery in order to comply with the terms of the law as to navigation. Meanwhile some of the lands along the canal have been leased for dock purposes, factory sites, etc., but are inaccessible as long as the bridges remain immovable. It has also been decided to extend the canal to Joliet, enabling ore steamers to deliver their cargoes direct at the yards of the steel works. In the annual report of the president of the Drainage District, Mr. McCormick, it is suggested that the legislature should be asked to extend the time for the opening of the canal for navigation for two years longer, or until 1909.

REINFORCED CONCRETE APPROACHES AND COLUMN FOOTINGS OF A STEEL VIADUCT AT KANSAS CITY.

By KENNETH HARTLEY.*

A steel viaduct has recently been completed for the Metropolitan Street Ry., of Kansas City, Mo., in the concrete approaches to which the avoidance of underground obstruction was accomplished by some novel methods.

The structure consists of 30 plate girder spans, aggregating 1,296 ft. in length between abutments, and is parallel to an old highway viaduct. The north approach, located on James St., Kansas City, Kan., provides for a roadway on the east side to connect with this old viaduct, as it was necessary to remove the old approach and build a combined approach for both viaducts in the center of the street. From this point the viaduct extends south, on the line of James St., over railroad yards to an intersection with West 12th St., Kansas City, Mo., and reaches the street surface near the corner of 12th and Genesee Sts.

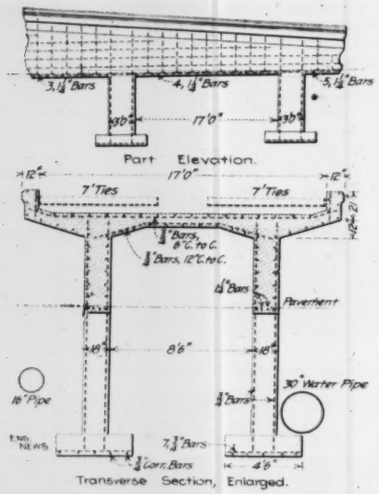

Fig. 1. South Approach of Kansas City Viaduct.

The typical construction consists of four lines of girders supported by two column bents, the columns extending to the top of the floor beams, with the outer stringers framing into the sides of the columns. Both the old and new column bents are supported on concrete spread footings.

SOUTH APPROACH.—It will be seen from the cross section of the south approach (Fig. 1) that to build retaining walls and fill between with earth it would have been necessary to move two water pipes, a 16-in. pipe on the north side and a 30-in. pipe on the south side. After considering various plans for carrying the walls above the mains, any of which plans would probably have cost more than moving the pipes, the design shown in Fig. 1 was finally adopted.

The structure consists essentially of a pair of continuous T-shaped concrete beams, one under each track, supported at intervals of 20 ft. by concrete piers. The excavation for the piers was carried just low enough to permit the footings to extend beneath the 30-in. water main. As there is no lateral pressure on these piers the load is distributed uniformly over the footing, 4 ft. 6 ins. by 6 ft., and amounts to about 2½ tons per sq. ft. The pier, 1 ft. 6 ins. by 3 ft., rises from the center of the footing and just clears the bell of the 30-in. pipe. The minimum depth of the T-beam is 45 ins. from the top of the floor slab, but where the height above the street surface is greater than this the bottom of the beam is brought down to the ground to give an appearance of solidity. The top flanges of the two beams are united, forming a continuous floor under both tracks. On this was laid 6 ins. of crushed stone ballast under the ties.

NORTH APPROACH.—At the north end of the viaduct the 30-in. water pipe is again in the way this time on the east side, but the method of construction used for the south approach could not be economically applied here on account of the greater width of the structure at this point. A filled approach was therefore necessary, but heavy retaining walls would have required a pile foundation which would have involved considerable risk of injury to the water and gas mains. To avoid this, light walls, 12 ins. thick, were built and tied together with cross walls at intervals of 16 to 20 ft. (See Fig. 2.) These tie walls were reinforced with sufficient steel to resist the entire horizontal pressure of the filling and the moment due to the overhang of the roadway on the east side, the piers merely carrying the weight of the walls. The side walls are of uniform thickness throughout, but the reinforcement varies with the height, being sufficient to transmit the maximum earth pressure to the cross walls, the side wall acting as a beam between these points.

TWIN FOOTINGS FOR VIADUCT COLUMNS.—On account of the small distance between the east columns of the new viaduct and the west columns of the old, it was impossible to place a footing symmetrically under the columns. The two columns of each bent were therefore placed on a single footing 6 ft. 6 ins. by 20 ft., as shown in Fig. 3. The two piers are close to the ends of this footing but are connected by a rib 15 ins. thick and about 3 ft. high reinforced with three 1¼-in corrugated bars, the rib and footing together forming an inverted T-beam which distributes the pressure uniformly over the entire base area.

*Structural Engineer Metropolitan Street Railway Co., Kansas City, Mo.

A SIMPLE CARBON MONOXIDE INDICATOR.*

Some forms of simple apparatus capable of indicating the presence of carbon monoxides in the air, and of measuring its amount, has long been sought. Albert-Levy some time ago showed that the gas is dangerous even when present in quantity much less than would cause immediate death, traces being serious if a prolonged sojourn be made in an atmosphere so contaminated. He has now devised a very compact and accurate piece of apparatus for determining the monoxide and one capable of being used by any intelligent foreman.

The air to be examined is aspirated through a tube packed with glass wool, which frees it of dust. This is accomplished by allowing water to flow from an aspirator bottle. The filtered air then traverses a tube filled with anhydrous iodic acid which is heated between 70° and 80° C. by a small alcohol lamp. By such passage the monoxide is oxidized to carbon dioxide and free iodine is liberated. This iodine, carried forward by the current of air, is arrested by solution in a little chloroform contained in another tube. The color produced in the chloroform by the iodine becomes distinct when dissolved therein, is compared with a set of standard colored tubes previously prepared and kept on hand. To prevent evaporation of the chloroform it is covered with a layer of distilled water.

*Abstracted from La Technique Sanitaire, May, 1906, by Prof. Wm. P. Mason, Rensselaer Polytechnic Institute, Troy, N. Y.

A LARGE BOND ISSUE FOR PARKS for Oakland, Cal., was approved by popular vote on Jan. 15. The amount provided is $992,000, which will be sufficient to purchase a large part of the park lands recommended by Mr. Charles Mulford Robinson, of Rochester, N. Y., in a recent report embodying a plan of civic improvement for the city of Oakland. In the course of his report, after alluding to the natural features of Oakland, Mr. Robinson said:

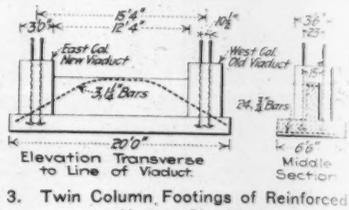

Fig. 3. Twin Column Footings of Reinforced Concrete, Kansas City Viaduct.

And yet to their glorious water front on one of the most beautiful bays of the world the people of Oakland have no access. There is not a spot on all the long bay and estuary frontage where they are free to watch the ceaseless panorama of the shipping. And on those hills, with their noble views and romantic glens, there are no free pleasure grounds to which they have inalienable rights; no walks and drives save the lines of direct travel; no seats; no lovely site, except the highways, which private ownership may not if it pleases fence off from public trespass, or use for the erection of signs that with hideous commonplaceness would unescapably dominate the town.

He discussed at length, in the course of the report mentioned, the possibilities in the way of park development, and also outlined a plan for the establishment and improvement of a civic center. The latter would be developed by grouping city buildings in the vicinity of the post-office and opening up a new street to connect public buildings.

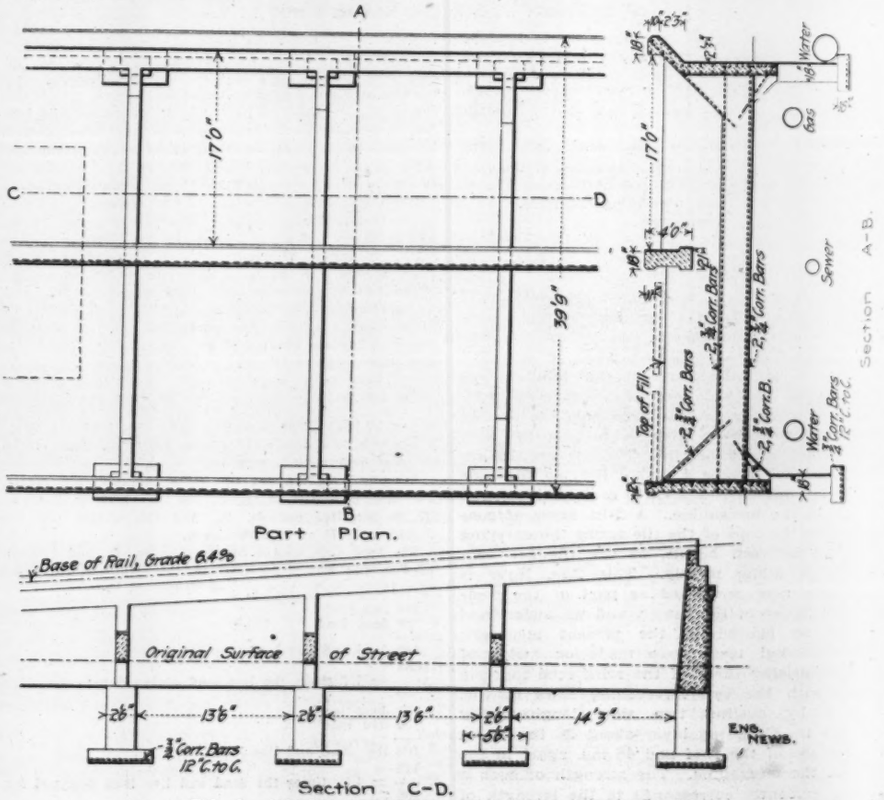

FIG. 2. NORTH APPROACH OF KANSAS CITY VIADUCT.

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A popular vote was taken at the Ontario elections recently held on the question of whether the individual cities and towns should or should not contract for the purchase of electric power from the Hydro-electric Commission (provincial). As a result nearly every city gave emphatic assent, stating in effect that if the commission will build transmission lines and deliver power from Niagara Falls at a local transformer station at a price as estimated—some $18 to $20 per horsepower-year—the respective city would certainly enter into a long-term contract with the commission to take a specified maximum of power at the fixed price, for local municipal (and other?) uses.

The appointment of the commission was itself the direct outcome of public sentiment in favor of making the undeveloped power of Niagara a working asset of the people. The recent popular vote is a great reiteration of the vitality of that sentiment.

Almost at the same time as this vote, has come a decision of Secretary Taft, of the U. S. War Department, reported in our last issue, relative to the use of Niagara water for power-development on the American side of the river and the transmission, across the border, of power generated on the Canadian side. This decision, in itself and as a concrete result of the Burton Act, expresses the policy of the United States government to strictly limit the draft of water from the upper Niagara River, so far as it is able to do so. The situation looks much as though no greater draft of water than is now permitted on the American side will ever be authorized by the Washington authorities. It substitutes fact for recommendation in the conclusions of the American half of the International Waterways Commission, the commission which presented a divided report on the Niagara question a year or two ago.

On the Canadian side of the Falls, the proposed governmental exploitation bids fair to bring about a concrete appreciation of the public benefits realizable from Niagara power development. One may foresee that this in turn will generate a popular enthusiasm for the utilization of the Falls of sufficient intensity to be seriously in the way of efforts at restricting the attenuation of the Falls. There can, of course, be not the slightest objection to the full present supply of Ontario province with power from Niagara; indeed, the world should find reason to be grateful to that movement for giving a demonstration of how well a public asset may be applied to the public needs. But before this demonstration creates excessive enthusiasm in the province affected, it is highly desirable that Ottawa and Washington should arrive at a calmly-considered conclusion as to the proper limitations of draft to protect Niagara Falls from practical destruction.

Twenty years ago, the problem which was exercising the whole engineering profession was how to transport passengers in city streets. The cable railway and later the electric railway enabled the solution of that problem; but the enormous growth of traffic which has resulted from this new and convenient method of travel has created new problems. Most of the larger cities to-day find their streets so congested at the centers where the electric car lines converge that the movement of traffic over the whole city is in some cases seriously hindered.

Probably the first city in the country to experience this difficulty was Boston, owing partly to its narrow streets and concentrated business district and partly to the fact that it was the first city in the country to adopt electric street railways on a large scale. It was this condition which led to the construction of its subway system.

The same trouble with traffic congestion at the business center which Boston experienced a dozen years ago is now reported from many cities. At Newark, N. J., for example, a city of some 300,000 population, all the street car lines in the city and its suburbs are brought to Broad and Market Streets, in the heart of the business district. The result has been traffic congestion and blockades on these streets which has recently compelled a change in car routes and the diversion of some of the car lines away from this central point. It appears to be a demonstrated fact that after a city exceeds a certain size it is no longer advantageous to concentrate all its lines of street car transit at the heart of its business district.

A rather peculiar instance of traffic congestion at the business center is found at Chicago on the elevated railway lines. That city relies for rapid transit on its four elevated railway lines and one or two of the main line railways, notably the Illinois Central. In the last few years the traffic of these elevated railways has increased greatly, so that, while ten or a dozen years ago they were much underloaded, they are at present badly congested in the rush-hours. More properly we may say that they would be congested if it were physically possible; but, unfortunately, these elevated roads were years ago saddled with the famous Union Loop, a double-track loop line used by all four of the individual elevated railways. Since the Union Loop was made the down-town terminal of all the elevated lines, each line has been able to get only its proportional part of the capacity of the loop. The disastrous effects of this throttling of the elevated lines have become apparent in recent years, and with the steadily growing traffic remedial action of some sort is imperative.

A specific solution of the loop difficulty was suggested in a report made to the City Council a year ago by a well-known Chicago engineer, Mr. B. J. Arnold. Briefly put, these suggestions involved lengthening the station platforms or interposing additional stations on the loop, and double-tracking the crossing points where trains enter and leave the loop at the southeast and southwest corners. These are evidently only makeshift remedies, merely mitigating the evils of the loop instead of eradicating it. Much more valuable is the further recommendation made by Mr. Arnold; namely, the through routing of traffic. This means for example running the trains of the Northwestern Elevated southward around one side of the loop and continuing them over the full length of the South Side Elevated. By this means the four lines would in effect be reduced to two, and the Union Loop, being double-track, would lose its character of a union trackage section, thereby increasing its capacity to the full capacity of the four lines.

An equally thorough but much more radical remedy is proposed by another Chicago engineer, Mr. J. B. Strauss, in an article presented elsewhere in this issue. The project which Mr. Strauss advances in definite form really involves two distinct steps in making a change from present conditions: First, the separation of the different elevated railway lines from each other so that there are no "union" sections of track. This he would accomplish by abolishing the Union Loop. Second, the provision of a union terminal station at which interchange between the several lines may be effected. These two ideas are the fundamental ones in Mr. Strauss' plan. The precise location of the new trackage required as a substitute for the loop is subsidiary, though from the local point of view it is undoubtedly a matter demanding very careful study.

The essential independence of the two parts of Mr. Strauss' proposals is recommended to the careful notice of the reader. The evils of the present system, from the viewpoint of traffic operation, are entirely due to the existence of union trackage, which requires the running of two elsewhere separate lines over a common section of track. When such a common section of track contains stations, the conditions for traffic operation on this section are identically those existing on either of the two tributary lines, and the train capacity of the union track is only that of a single line, so that the two component lines can each develop only half the normal line capacity.

We refer here, of course, to maximum capacity conditions, such as obtain in rush hours. Operation during the light-load hours will probably be much the same with or without a union section, and the earnings of a line may be but little reduced by the halving of the maximum capacity; but the public interest in morning and evening transportation—an interest which is of very great magnitude in the modern large city—is vitally affected by any reduction of maximum capacity. The reduction of capacity by union operation within a central district is an unwarrantable infringement on the legitimate claims of the community.

It is not our purpose to examine or comment upon the present project in detail. The joint terminal station idea, the precise character of the relocation of the individual lines, and the like, are so much matters for solution according to minor local conditions and desires that their consideration here could be of no interest. It may be conceded that any solution of the present situation properly requires a means of carrying passengers to the center of the business district, and means for transferring from one line to another so as to give direct transit from the north side to the south and west sides, etc. These results can be secured in a variety of ways with equal advantage to the traveling community. The crucial point is that with four individual lines in existence, and with a large and ever-increasing quota of daily travelers to and from the center of the city, steps should promptly be considered and initiated to change the system in such a way as to enable each line to develop its maximum train capacity. The abolition of the Union Loop, at least as a loop, is the *sine qua non* of this first pressing need.

The resignation of Dr. Chas. D. Walcott from the Directorship of the U. S. Geological Survey to accept the Secretaryship of the Smithsonian Institution, ought to call renewed attention to the absurdities of the present system—or lack of system—for the payment of those holding positions of great responsibility in the Government Service. The Director of the U. S. Geological Survey receives a salary of $6,000 a year, and is the executive head of a great organization charged with the responsibility of wisely expending about one and a half million dollars per annum in direct appropriations, besides the work of the U. S. Reclamation Service. For the carrying of such large responsibility in private business, a man would receive a salary of $10,000 to $40,000 a year. Dr. Walcott, after a dozen years of most valuable service at the head of the Geological Survey, now resigns to accept the

Secretaryship of the Smithsonian Institution at a salary of $7,000 per year, where his responsibilities will be, we should suppose, not one-tenth or one-hundredth as heavy as in the place he has left.

Congress has acted wisely, we believe, in increasing the compensation of Senators and Representatives to $7,500 a year instead of $5,000. The member of Congress, however, devotes not more than six months per year to the Government's service; and there are a considerable number of Government officers at Washington who carry a heavy load of responsibility the year round and who ought to receive pay proportional to the value of their services.

The prevalence of typhoid fever in many important cities of Pennsylvania is leading to some radical proposals for State legislation. The only one of these to assume the shape of a legislative bill, so far as we know, is one which provides that all passenger cars passing through the drainage areas of public water supplies in Pennsylvania must have their water closets equipped with water-tight receptacles to prevent the pollution of streams. This bill was reported by the Senate Committee on health and sanitation on Jan. 24. The bill is largely due, we presume, to the fact that both the Lackawanna and Erie railways pass through the drainage area of the Scranton Gas & Water Co., the water supplied by which company is believed to be responsible for more than 1,100 cases of typhoid fever and the 100 deaths from that disease that have occurred in Scranton since Dec. 1.

In our issues of Aug. 30 and Dec. 20, 1906, considerable space was devoted to the agitation at Seattle, Wash., caused by the proposed extension of the Chicago, Milwaukee & St. Paul Ry. through the Cedar River drainage area of the Seattle water supply. The many experts called in behalf of the public and of the railway agreed in recommending that special precautions be taken to prevent the pollution of the Cedar River by the construction and operation of the railway. The final agreement, we understand, provides for locking the doors of water closets while trains are passing for a dozen miles along or near the Cedar River, and in addition for solid floors for all bridges and culverts and special means to divert the roadbed drainage from the stream. Mr. John R. Freeman, in a report to the Washington State Board of Health, came out strongly against placing reliance on locking the water closet doors, urging that the protection thus afforded was uncertain and that the practice was unhygienic, in its relation to passengers. Prof. Wm. T. Sedgwick, who was a member of a joint arbitration commission, while joining the commission in its recommendations for locked closet doors and tight bridge floors, afterwards strongly declared himself (Eng. News, Dec. 20, 1906) against locking closet doors, either while passing through water-works drainage areas or through railway station yards. Instead, he urged that passenger trains be equipped either with dry earth closets or with water-tight tanks to receive the contents of water closets.

That the question is beset with many difficulties, particularly for the railway companies, can be readily seen. Possibly some sort of dry closet scheme might be worked out which could be taken care of in passenger terminal yards in a sanitary manner; but the difference between *could* be and *would* be is a large one. The protection from fouling of water courses and of railway crossings and yards in towns and cities is certainly a desirable end, and one which every sanitarian would desire to see accomplished. Any device or system to accomplish this, however, would have to be so arranged and operated that it would not create other, even though lesser, nuisances and dangers.

Kaleidoscopic changes have occurred in Panama Canal affairs during the past week. On Jan. 24 came the announcement that Mr. Theodore P. Shonts had resigned the Chairmanship of the Commission to accept the Presidency of the Interborough-Metropolitan Co., controlling the surface, elevated and subway lines of Manhattan Borough, New York City. As some of our readers will recall, this company was organized a year ago for the purpose of injecting some two hundred millions of water into the already diluted capitalization of the companies which control the means of passenger transit in New York City's streets. If Mr. Shonts can so administer the affairs of this ill-begotten corporation as to give New York a street transit service which will satisfy reasonable public demands, and if he can at the same time satisfy the holders of these watered securities and also the financial magnates who have employed him, he will have to his credit a more difficult feat than piling a dozen Culebra cuts on a score of Gatun dams.

It is announced, with every appearance of authenticity, that Mr. John F. Stevens, Chief Engineer at Panama, is to be made Chairman of the Commission to succeed Mr. Shonts, and that other vacancies in the Commission are to be filled by promotion of several bureau chiefs at Panama. Apparently the working organization to construct the canal is in future to have its headquarters on the Isthmus and not at Washington.

Of little less interest to the engineering world is the announcement, on Jan. 27, that the low bid of Messrs. Oliver and Bangs for the canal work had been rejected; but that Mr. Oliver's personal and financial standing had been found unexceptionable, and that he would be given an opportunity to find new partners in place of Mr. Bangs to carry out the contract. The official statement on this matter is as follows:

As a result of conferences at the White House it was announced on Jan. 27 by the Isthmian Canal Commission that, in view of assurances which had been received from Mr. Oliver and capitalists associated with him, that Mr. Oliver was prepared to make good his bid to complete the construction of the Isthmian Canal at a percentage of 6.75, with an organization of contractors and with financial resources in full compliance with the requirements of the invitation for bids, he will be given an opportunity to do so.

Mr. Oliver has been notified that within ten days he will be required to associate with himself at least two independent contractors whose skill and experience combined with his own shall cover the entire field of work to be performed under the contract, and to organize a corporation for the express purpose of carrying out the proposed contract, with a capital of $5,000,000, of which not less than $1,500,000 paid in cash, and $1,500,000 in the form of solvent subscriptions, shall be available for the purpose of carrying out the contract, and of which the remaining $2,000,000 may be devoted to the purpose of procuring a bond, as required by the contract, or of substituting in lieu thereof, in whole or in part, subject to the conditions of the bond, cash or current securities satisfactory to the commission.

Satisfactory assurances not having been received that the financial standard of Mr. Anson M. Bangs met the requirements of the invitation, by direction of the President he has been rejected as a participant in the bid filed by Messrs. Oliver and Bangs.

The privilege has been extended to Messrs. MacArthur and Gillespie, the one remaining bidder whose bid has been deemed worthy of consideration, to either withdraw their pending bid or to allow it to abide by the result of Mr. Oliver's efforts to make good his bid as herein outlined, then to be considered upon its merits. The other bids have been rejected because informal, and in the case of the highest bid, excessive as well.

The foregoing action is taken in conformity with the expressed wish of both Mr. Oliver and the MacArthur-Gillespie syndicate that the contract should be let without a rebidding, and in view of the further statements of the spokesman of the MacArthur-Gillespie Company to the President that if the commission could close the contract with a satisfactory and responsible association or contractor at a rate as low as that proposed by Mr. Oliver it should feel at liberty, so far as they were concerned, to do so.

While failure to furnish satisfactory financial statements is alleged above to be the reason for rejecting Mr. Bangs as a bidder, it appears likely that he may have suffered from his business association some years ago with John H. Gaynor and B. D. Greene, now serving sentences in the Atlanta penitentiary for conspiracy with ex-Capt. O. M. Carter to defraud the Government in the Savannah Harbor and Cumberland Sound contracts. Gaynor is a brother-in-law of Bangs, and Bangs was a guarantor on some of the bids of Gaynor's concern for work in the Savannah district, while Gaynor and Greene were sureties on several Government contracts taken by Hughes Brothers & Bangs. While Bangs' name appeared in the charges for conspiracy on which Carter was court-martialed, it has never appeared that Bangs or his partners were in any way associated with or responsible for the frauds practiced by the Atlantic Contracting Co. Nevertheless, in letting the contract for the Panama Canal, the fidelity and probity of the contracting firm is an element of great importance in view of the searching public scrutiny which everything and everyone connected with the work is certain to receive. Even an innocent connection with a concern convicted of defrauding the Government, therefore, would be a most undesirable handicap for a Panama Canal contractor.

THE BROOKLYN BRIDGE TERMINAL PROBLEM.

The longest engineering problem that we know of is the problem of the Brooklyn Bridge terminal in New York City. This problem has been before the engineering profession in a more or less aggravated form now for more than twenty years. It has been tackled by all grades of engineers from the lowest to the highest. Solutions innumerable have been brought forward, by experts and by amateurs, by engineers, politicians, business men, architects, clergymen, lawyers—in fact, by members of about every trade or calling under the sun.

Quite a number of solutions have been put into practical effect, but the problem has bobbed up anew in a short time, and is to-day more insistent and terrible than ever before. In other words, as fast as any new means for handling the traffic has been furnished, the traffic has grown by leaps and bounds until in a little while the crowding has become worse than ever.

It is now nearly a quarter of a century since the Brooklyn bridge was opened to the public. Prior to its completion the ferries across the East River were the sole means of travel between New York City and Brooklyn. At that time horse cars were the best means of street travel available. Electric cars were unheard of, elevated roads were just beginning to be experimented with, and the cable road, crossing the bridge and ending in a terminal station at each end was at that day a great feat of engineering.

It was on Sept. 24, 1883, that these cable cars began running, and in 1884, the first year of full operation, they carried eight and a half million passengers. The next year the number was doubled. In 1886 there were twenty-four million people carried, and the maximum rush-hour traffic was 7,870. The Brooklyn Bridge problem began then and it has continued ever since.

We say the problem began then; but looking back now, the passenger traffic which was then carried seems so trifling compared with present day crowds that we wonder its handling was considered a matter of any difficulty. Actually, however, there was 20 years ago a crush at the Brooklyn Bridge terminal. In testimony of this fact we print here the following extract from the New York "Times" of Oct. 31, 1887:

The scenes daily witnessed by those who ride across the Brooklyn Bridge between 5 and 7 in the afternoon cannot be duplicated elsewhere, not even on the uptown platforms of the elevated railways. The struggles to get aboard—nobody attempts to get a seat except by chance—resemble a series of "scrapping matches" more than anything else. Some fight with the ever-ready policemen; others wrestle among themselves in the doorways, each one making entrance with a pop as audible as the extraction of a champagne cork. No man of adult dignity enters that human maelstrom with even a chance of preserving his back and stomach from desecration by extraneous elbows. No woman there dares to hope that sex or weakness will protect her from physical collisions, which often are so violent as to be dangerous, and are always personally offensive. We ask no individual's pardon for remarking in a general way that only persons of considerable strength of body and rather weak minds would engage in that sort of thing day after day. They must be strong for otherwise they could not survive it. And they must be weak-minded or they would demand a remedy, in tones which would

be understood even by the obtuse managers of the busiest railway thoroughfare in the world.

Let us see what this crowd at the Brooklyn Bridge in 1887 looks like in actual figures. At that time the cable cars were the only means of transit across the bridge except the footway, and a separate three-cent fare was charged. Thus exact figures of the traffic at that date are obtainable and they are as follows: The total number of passengers carried in the year 1887 was 27,940,000, a daily average of 91,130. The maximum rush-hour traffic (nearly all in one direction of course) was 10,086 persons.

Contrasting now these figures with the travel of the year 1906, we find that the bridge travel in the latter year was OVER FOUR TIMES AS GREAT. The official figures for 1906 are: Average daily travel, 390,582 persons. Maximum rush-hour travel, 47,856.

If the Brooklyn Bridge entrance was, as the "Times" said, "a human maelstrom in 1887"—and there are survivors who can testify to the accuracy of that description—what is it in this year of grace 1907, when nearly five times as many human beings crowd through it every morning and every night? It is small wonder that the Brooklyn Bridge terminal crush has become the one great topic of interest to the people of that borough, and that all the preachers in that city of churches recently devoted a Sabbath to a scathing indictment from their pulpits of whoever was responsible for the existing conditions.

Of course, it goes without saying that the traffic across the bridge could not have been quadrupled if the facilities for travel had remained the same now as 20 years ago. It will be of interest therefore briefly to review the changes that have taken place.

When the cable railway across the bridge was opened on Sept. 24, 1883, two-car trains were operated for a couple of months and then three-car trains were run. In 1887, these trains were operated under a 90-second headway (theoretically); and in 1888 some changes in the terminal platforms made possible the running of four-car trains, which have since been in use. For a dozen years from the time these cable cars began running, the trains were switched at the terminals from the incoming to the outgoing track by steam locomotives. At the close of 1896, electric motors were placed on the bridge cars, and switching by locomotives became no longer necessary. This so simplified the movement of trains at the terminals that the headway between trains was cut down to 60 seconds and even less at times. About a year later (on Feb. 16, 1898) the Brooklyn trolley cars began running across the bridge to the Manhattan terminal on tracks laid on the bridge roadways.

The effect of these additional facilities on the growth of traffic was soon seen. In the nine years from 1887 to 1896, the daily traffic increased only from 91,100 in the former year to 144,500 in the latter. Four years later, in 1900, the daily traffic was 275,800. Six years later, in 1906, the daily traffic had grown to 390,500, and the Brooklyn Bridge terminal problem assumed an urgency that was undreamed of twenty years ago, when conditions were thought to be so bad.

We risk little in saying that nowhere in the world is there any such concentration of passenger traffic as exists at this Brooklyn Bridge terminal. It may be explained, too, for the benefit of readers unfamiliar with New York City, that close beside this terminal and forming part of the same building is the main downtown terminal of the Second and Third Avenue lines of the Manhattan Elevated Ry. Co. In addition, the Rapid Transit Subway has an underground station immediately adjacent and on the surface of the street pass the lines of the Second, Third and Fourth Avenue electric cars. Altogether the swollen river of people which surges toward this spot at night and away from it in the morning is a sight to be seen nowhere else.

Many of our older readers may recall the special interest which the late A. M. Wellington, when Editor of this journal, took in the Brooklyn Bridge problem in the late '80's and early '90's.

It was his belief and prediction that the future development in population of Greater New York would be chiefly on the Long Island area; and this has been fully verified by the course of events, although the rate of Brooklyn's growth has been undoubtedly retarded by the inadequate facilities for transit to and from the island of Manhattan, as already explained. In the pages of this journal, in our issue of March 17, 1888*, an estimate was made of the future traffic over the Brooklyn Bridge. We have deemed it worth while at this time to print these figures and with them the figures of actual traffic so far as they are obtainable. While the actual traffic over the bridge is somewhat less than the estimated, it is fair to say that the estimates were made on the assumption that a radical improvement was to be made at that time in the bridge terminals, sufficient to enable all the traffic to be comfortably accommodated.

So much for the past. Looking now to the future it is a pleasure to be able to say that the Brooklyn Bridge terminal problem is at last to be solved in a manner which will, we believe, remove it permanently from the field of public discussion. We print in this issue the plans adopted for the improvement. They have the merit of providing a great increase of ground space, and of handling the traffic on three different levels.

To refer again for a moment to past history, however, these same features were embodied in the plan prepared for this terminal by Mr. Wellington twenty years ago, which was rejected on account of the large expenditure required. At the time Mr. Wellington's plans were made, the land needed for the enlarged terminal building which he proposed was covered with old buildings of little value. Just at that time, however, one of the tracts necessary for the enlarged terminal, which he proposed, was secured by the New York "World"; and as soon as Mr. Wellington's plan was made public, that journal savagely attacked it. This and other causes led to the final defeat of the plan, and the result has been twenty years of crowding on the old terminal station site and a delay for that length of time in creating the spacious terminal that was recommended so long ago.

Turning again to the present plans to provide for the traffic, it is to be noted that during the past year, five-car trains have been operated over the bridge in place of the four-car trains used since 1888. These trains run on a 55-second headway and each car can carry 150 passengers (seats and straps combined!) The headway between trolley cars has also been decreased during the past year, so that a maximum of 326 cars per hour can be moved across the bridge. It may be assumed that these figures represent about the maximum possible traffic that can be moved over the four tracks now available on the present Brooklyn Bridge.

If this were all, we may be sure that the growth of traffic would shortly again swamp the facilities for handling it; but this is not all. At present the Brooklyn Bridge used to its full capacity, and the Williamsburgh bridge, used only partially, are the sole arteries for communication between Brooklyn and Manhattan. To divert some of the traffic to the northerly bridge, and particularly to lessen the crush at the bridge terminal, the Board of Estimate this week voted funds to build a four-track subway connecting these two bridges. Much more important, however, are the new arteries which will shortly be opened over and under the East River. These are the double-track Rapid Transit tunnels from the Battery to Brooklyn, the four-track Pennsylvania R. R. tunnels at 34th st. and the two-track Belmont tunnel so-called a little farther north. In addition there is the great Blackwell's Island cantilever bridge, the superstructure of which is now being erected and the Manhattan Bridge, near the old Brooklyn Bridge, which is now under contract. Thus to sum up, while there are now only two bridges with a total of ten lines of railway tracks across the East River, there will be, only three years hence, four bridges and three tunnels with a total of some 40 railway tracks available for traffic.

It may surely be expected, therefore, that the long Brooklyn Bridge terminal problem is soon to cease from troubling and like all things else find its end.

*P. 198.

PASSENGER TRAFFIC ON THE BROOKLYN BRIDGE.

Year.	Annual total. Mr. Wellington's Forecast.	Annual total. Bridge Commissioner's report.	24-hr. total daily average. Mr. Wellington's Forecast.	24-hr. total daily average. Bridge Commissioner's report.	Maximum total rush hour traffic. Mr. Wellington's Forecast.	Maximum total rush hour traffic. Actual count.
1883.....	....	1,082,300	....	....	....	1,560
1884.....	....	8,529,840	....	25,300	....	3,709
1885.....	....	17,177,053	....	36,511	....	4,725
1886.....	....	24,029,267	....	70,237	....	7,870
1887.....	....	27,940,313	....	91,130	....	10,086
1888.....	32,474,330	30,331,283	88,980	98,127	10,944	11,413
1889.....	37,345,480	33,954,773	102,320	110,234	12,585	13,355
1890.....	42,947,300	37,676,411	117,660	122,298	14,472	14,095
1891.....	49,389,400	39,796,043	135,310	123,966	16,642	14,818
1892.....	56,797,810	41,772,898	155,610	129,382	19,140	17,013
1893.....	62,477,590	42,615,105	171,170	127,237	21,054	16,179
1894.....	68,725,350	41,704,235	188,280	135,549	23,158	15,734
1895.....	75,597,890	44,564,329	207,120	133,077	25,476	16,899
1896.....	83,157,670	43,996,459	227,830	131,281	28,023	15,418
1897.....	91,473,440	45,542,627	250,610	144,509	30,325	17,218
1898.....	....	*19,454,757	....	†....	....	†12,264
1899.....	....	....	....	†....	....	‡....
1900.....	....	....	....	275,823	....	‡....
1901.....	....	....	....	283,064	....	‡....
1902.....	....	....	....	307,297	....	40,626
1903.....	....	....	....	321,429	....	41,591
1904.....	....	....	....	356,976	....	46,847
1905.....	....	....	....	356,308	....	47,455
1906.....	....	....	....	390,582	....	47,856

*The operation of the Bridge Railway was assumed on June 30, 1898, by the Brooklyn Rapid Transit Co., and no annual record was kept after that date.

†Trolley car service on the Bridge Roadways began February 16, 1898, and no count was taken of the total daily average during 1898 and 1899.

‡No rush-hour count was taken during 1899, 1900 and 1901.

LETTERS TO THE EDITOR.

A Formula for the Crown of Paved Streets.

Sir: On page 20 of Engineering News for Jan. 3, 1907, appears a formula for the crown of paved streets, submitted for criticism by Mr. J. E. Borden, about which I would remark; there is one factor, "g" [coefficient for varying street grades that decreases as grade increases] in the expression which has so very slight an effect on the result as to make it altogether useless. Its omission would considerably simplify the formula, without changing the result appreciably.

Remembering that the grade of a road is a ratio commonly expressed as a percentage or as a decimal it is quite evident that the effect of this factor is negligible under any practical conditions. Consider two pavements of extreme width, say 100 ft., between curbs, so that the crowns and the difference between the crowns will be greatest to be found in practice. Assume one pavement on a grade of as much as 20% or 0.20 to have an extreme condition, the other pavement on a level grade. Substituting 0.0 and 0.20, consecutively, in the formula for "g" and the resulting values in formula for "c" we obtain crowns differing by 0.01b ft.—hardly ¼-in.!

Yours truly, F. L. Brown.

Chicago, Ill., Jan. 18, 1907.

Empirical Formulas for Stresses in Chimneys.

Sir: With regard to Mr. Charles B. Buerger's letter in your issue of Jan. 3, 1907, in regard to "The Design of Reinforced Concrete Chimneys," there is an interesting analysis of the stresses and some pertinent editorial comment thereon. Several years ago Prof. Lang produced

an interesting monograph on chimneys which was translated and appeared in "The Engineering Record." Since that date I believe this treatise has been revised, but it has not to my knowledge appeared in English. Prof. Lang limited the applicability of his formulas to cases in which the temperature of the waste gases does not exceed +570° F. These formulas apply to brick chimneys and are as follows:

$$p = 71 + 0.65\ H \qquad = 18.5 + 0.056\ H$$

for unlined chimneys, and

$$p = 85 + 0.65\ H \qquad t = 21.3 + 0.056\ H$$

for chimneys with an independent lining.

In these formulas

p = vertical compression, in lbs. per sq. in.

t = vertical tension, in lbs. per sq. in.

H = height of the chimney above the point being investigated, in feet.

In using any chimney formulas the initial compression cannot be neglected. Neither can the fact be overcome that planes of separation are extremely liable to occur in any concrete structures, no matter how carefully they may be guarded against in the specifications and inspection of the work. Another element which must be taken into account is the temperature of the waste gases. The builders of brick chimneys have learned by sad experience many things which the concrete chimney builder has yet to discover. A. D. W.

New York City, Jan. 19, 1907.

Slope Protection for the Empire Reservoir Embankment, Colorado.

Sir: I have read with interest the article in your issue of Jan. 3, on the Empire Reservoir of the Bijou Irrigation District, Colorado. Will you ascertain from the author what method, if any, has been considered necessary to prevent damage to the several earth dams from the action of waves during periods of high winds—as I notice the cross-section shows "no slope protection."

"Engineer."

Canada, Jan. 10, 1907.

[We append a reply, kindly sent at our request by Mr. Page.—Ed.]

Sir: Replying to "Engineer's" inquiry, I would say that an 8 to 1 slope was thought at one time to be a stable water slope for any reservoir; but experience has proven that it is not for embankments to large reservoirs where there is considerable wave action. However, it certainly stands better than a steeper slope.

There is no suitable riprap material in the neighborhood of the Empire reservoir. It is five miles over poor roads to the nearest railway point and thence 75 miles by rail to the nearest stone quarry. Earth was really the only available riprap, hence the slope below high water line was made 8 to 1, the width of embankment at high water line being 58 ft. It is believed that this protection will suffice for at least two seasons. At the end of that time the several embankments, it is thought, will be well soaked and settled, in better condition to receive riprap; and, what is of still greater importance, the nature and extent of the needed protection will be much more manifest.

We have not always found stone riprap adequate protection in this country unless put on very thick. I am watching with considerable interest experiments that are being made near here with reinforced concrete on 1½ to 1 slopes. The ice and frost of this winter will, I believe, if followed by high winds before the ice disappears, be a valuable test of its efficiency as a riprap for reservoir embankments.

C. D. Page,
Civil and Irrigation Engineer.

Greeley, Colo., Jan. 17, 1907.

Burying Street Railway Ties in Concrete.

Sir: In your issue of Jan. 17 I notice your comment upon the practice of burying wood in concrete in street railway track construction.

In 1892, when the present Toronto Street Ry. Co. converted the old horse car line into an electric line, the city in connection therewith constructed a permanent pavement, the railway company putting down the wooden ties and rails. The ties were supposed to be placed on a bed of sand and gravel 3 or 4 ins. deep, but in some cases they were put upon natural soil; concrete was then placed around the ties, but none under them. Upon frequent occasions we have examined these ties and none have been subject to dry rot. In most cases the ties were full of moisture and in sound condition. The ties were cedar. We have, however, since abandoned this form of construction and now lay the rails on a concrete beam 12 ins. deep and use steel tie-bars spaced about 6 ft. apart.

Yours truly,
C. H. Rust, City Engineer.

Toronto, Ont., Jan. 19, 1907.

Sir: Referring to your editorial in Engineering News of Jan. 17 regarding recent track construction on Washington St., Boston, it may be of interest for you to know that the bedding of the wooden ties in concrete was no experiment, as this same length of track on Washington St. was laid on untreated wooden ties bedded in concrete in 1892. When it became necessary to relay the rails six years later, the ties were found in sound condition so that new rails were laid on the same ties without having to disturb them.

How long they would have lasted can never be told, as the entire surface of the street was destroyed in connection with the building of the tunnel and an entirely new track has just been laid. When the ties were taken out after having been in the concrete 14 years, they were found in good condition and if the street had not been disturbed, would have lasted for several years more. We have never discovered any indication of dry rot in any ties laid in concrete in our streets.

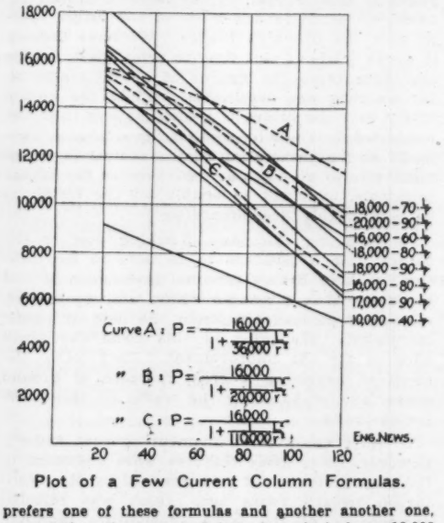
Regarding the expense of wooden ties, they cost but little more than the concrete which they displace, so that there would be very little economy in reducing the number of ties.

Yours truly,
S. L. Plimpton, Civil Engineer.

101 Milk St., Boston, Mass., Jan. 24, 1907.

What Column Formulas Shall be Recommended for Practical Designing?

Sir: Your long editorial on "Column Formulas" is interesting to those who like that sort of thing, but what the engineer would like to have is not more theory as to the proper theory upon which to build a formula; what he does want is two or three good working formulas, instead of forty or fifty that are now to be found scattered throughout engineering literature. I enclose a rough sketch of a diagram I have made from some of the formulas given in your article. For the curved-line formulas, I have taken only S = 16,000 and B = 36,000, 20,000 and 11,000. If S had been taken at some other figure, the curves would have shown still wider variation. The straight-line formulas taken are shown on the diagram. It will be observed that if one engineer



Plot of a Few Current Column Formulas.

prefers one of these formulas and another another one, even within the range of formulas which have 16,000 or more as the starting point, there may be a difference of more than 25% in the weight of two columns designed for equal loads. If the formula giving the lighter column is correct, then the other one wastes 25% or more of the material. Surely this cannot be a satisfactory state of affairs. It seems to me that the writer of the editorial should go further than he has and make an investigation for the purpose of discovering, if possible, what column formula should be used to give safety, and, at the same time, economy of material. It might be well to get up a symposium on the following question:

Given a steel of 64,000 lbs. tensile strength, 40,000 lbs. elastic limit, and a factor of safety of 4, what is the best formula for designing a column made of this steel, and why is it the best?

A set of good answers to this question would be of far more value to the engineer than the whole series of formulas given on p. 18 of your issue of Jan. 3 without any hint as to when one of these formulas should be used and when another one.

Very truly yours,
Wm. Kent.

Syracuse, N. Y., Jan. 14, 1907.

The question suggested above as a good one for a symposium is hardly definite enough to lead to useful results. Uncertainty is introduced by the words "factor of safety of 4." We discussed the subject of factors of safety at considerable length in our issue of Sept. 6, 1906, with just the purpose of showing that "factor of safety" is often a dangerously misleading t The present case is an instance where its leading character is prominent. Does Prof. Kent mean that the load is to be one-fourth failure load, or does he mean that the maxi fiber-stress is to be one-fourth the ultim The two things are radically different in the of eccentrically-loaded columns.

If the question be cleared of its indef character, its discussion could not fail to b teresting.—Ed.]

A Notable Early Instance of Reservoir Stripp

Sir: Among examples of reservoirs which have prepared for the impounding of a supply of water domestic use by the removal of soil [see Eng. News, 3; 1907] I have not seen any mention of the Fairv Reservoir of the water-works of Norwich, Conn.

Not only was the brush removed and stumps grub in this case, but the soil containing organic matter also quite thoroughly removed. According to the re of the engineer, more than 300,000 cart loads were cavated from the basin over an area of 66 acres.

This work was done in 1868, under the direction of engineer, Mr. J. T. Fanning, who designed the en system. It is believed that the Norwich water-works Col. Fanning's first undertaking as a hydraulic engine After 38 years, when the water is drawn low, little b boulders and gravelly soil is to be seen on the exposed bo tom. Almost no vegetation appears in the basin, even when the water remains low during the whole of the warm season.

Observations to show the amount of water that has been obtained from this supply have never been made. It is evident, however, that much more per square mile of drainage area has been used than is reported as obtained from the Sudbury works. The reservoir was built to contain 350,000,000 gals. and has been enlarged in capacity by building the dam higher. As a consequence of the large draft upon the supply, it is drawn down to less than 100,000,000 gals. in storage for long periods at one time.

The clean character of the basin is especially desirable when, as in this case, there are long periods when but little benefit can be had from the improvement which would be given by storage in a full reservoir more than 30 ft. in depth.

Yours truly,
Geo. E. Manning.

Yantic, Conn., Jan. 5, 1907.

[Mr. Manning's interesting letter was referred by us to Mr. Fanning, with the request that he submit further information on this subject for the benefit of our readers. This he has kindly done. In addition to the information given in the two letters we may state that according to a description of the Norwich water-works, by the late J. J. R. Croes (Eng. News, July 30, 1881), the flow line wall mentioned by Mr. Fanning was 2½ miles long; also that two small "filtering dams" were built, one at the entrance of each stream feeding the reservoir. Mr. Fanning's letter follows.—Ed.]

Sir: In response to your request for some data relating to the stripping of the reservoir at Norwich, Conn., and also because of the interest just now awakened in the desirability of cleaning the bottoms of storage reservoirs by the recent exhaustive advisory report, relating to the Ashokan Reservoir, by Messrs. Allen Hazen and Geo. W. Fuller, Ms. Am. Soc. C. E., I present the following descriptive statements:

Forty years ago, in 1867, the surveys were made and the construction of the Norwich water-works was ordered by the city council. The lakes and ponds nearest to the city, that were adapted to furnish the city with a supply of water, were so far away that the cost of the supply main from either of them to the city made those sources prohibitive, for cast-iron pipes were then selling at about $60 per ton, and 16 and 20-in. pipes, such as were required for long mains, would cost approximately $23,000 and $32,000 per mile.

The alternative was to create a gathering and storage reservoir on a very limited drainage area near the city and adapt the reservoir basin to serve also as a distributing reservoir. The drainage area was so limited it was anticipated that within ten years the water consumption would increase to within 30 to 40% of the rainfall on the catchment area and that in time there might not be any overflow from the reservoir during several successive years. Hence pains were taken to adapt the reservoir in advance to such exacting conditions.

A dam 30 ft. in height created a storage lake of 6 acres in a narrow valley, with a storage capacity o 333,000,000 gals. In the bed of the valley there had, i earlier days, been a shallow mill pond and in this mi pond bed there had accumulated a depth of from 10 to 2 ins. of muck, which later, after the mill and pond disap

peared become a "bog meadow" and brush land. This muck covering nearly 30% of the reservoir area, was entirely removed. A portion of the side slope of the reservoir was hardwood forest and a part pasture and brush land. The trees and brush and about 20,000 tree stumps were removed. The soil on the side slopes was removed also as clean as possible to the underlying drift gravel. The stripping on the reservoir bed exceeded 100,000 cu. yds. of soil and meadow earth. The stripping uncovered numerous granite boulders on one side of the basin and these were used in the construction of a shore wall entirely around the reservoir, so placed as to prevent shallow water along the shore.

In anticipation of a considerable fall of the surface of the water in the dry portions of each year and also because of the conclusion that the best part of the stored water would generally be found a little under the surface, just below reach of floating matters, the effluent pipe leading water into the city main was hinged in a Y-joint at its base, so that its strainer bulb might be frequently adjusted to rest in the best stratum of water.

The Norwich reservoir has been in constant use during the forty years since its construction and it is believed that the thorough care in its construction details has protected the citizens of Norwich from many of the "cucumber and fishy taste" troubles, such as are often reported in connection with other pond water supplies.

Yours respectfully,

J. T. Fanning, C. E.

Minneapolis, Minn., Jan. 10, 1907.

How Far Is the Water-Works Engineer Responsible for Typhoid Fever Epidemics?

Sir: Apropos of the conditions in a city in which an epidemic of typhoid fever is raging at the present time, and in hope that the ethics of the civil engineering profession will not be violated by a pertinent query, the writer wishes to give a brief outline of the case and to ask how far does the ethical responsibility of the engineer-in-charge of the water supply system extend.

The city referred to above is an inland city with over 100,000 population and is supplied by a private water company, owned practically by one man. The greater part of the city is supplied from three reservoirs, two of which, one below the other, are supplied entirely by and lie on the same brook, just below its junction with another brook, the third reservoir being connected with the first two.

Prior to the summer of 1906 it was the boast of the city that its water supply excelled in purity that of any other city in that portion of the country. The foundation for this boast rested on the fact that for the greater part of the year the water was clear and cold and tasted well. Even when the reservoirs were "working" the water lost little in clearness and had but a slightly disagreeable taste.

Last summer a short article appeared in the daily papers stating that a bacteriologist employed by the water company pronounced the water in all reservoirs but one in fine shape, and that the water in that one, while not dangerous to health, was not of as good a quality as the others.

No special significance was attached to this statement by the public or the press, but a short time later one of the distributing reservoirs was drained off and the bottom cleared of roots and washed by hydraulic process. During the cleaning of the bottom heavy rains caused the water in the brook to rise several times, and, the outlet at the dam being inadequate to carry off this full flow of the brook, the water rose in the reservoir until it went over the dam, and at the same time filled the intake chambers.

Whether or not any of this water got into the pipes of the system and reached the city depends, of course, on the system of valves and connections at the reservoir. It is said that the connections were such that this water reached the city. The writer has no authoritative information as to the connections, however. This cleaning was in progress when the epidemic broke out.

Early in December, 1906, an enterprising reporter of one of the daily papers, while in conversation with a physician, discovered that the latter had several cases of typhoid fever among his patients; more than he had ever had at one time before. The reporter found other physicians who had typhoid cases, but they were so scattered that no special importance had been attached to them.

An article in the daily paper suggesting an epidemic prompted the board of health to urge all physicians to report at once, and daily thereafter, all cases of typhoid they were called to attend. In a few days it was realized that typhoid was prevalent in epidemic form. The board of health immediately issued a warning against the water, and impressed upon the people through physicians and the press the usual precautions. A careful examination of the milk supply failed to reveal possible sources of infection.

The implication that the water was responsible for the epidemic was indignantly denied by the owner of the water company, who stated that he had been drinking a large number of glasses of water every day and would continue to do so. He submitted samples of water to a chemist for examination and the latter reported no typhoid bacilli. The city bacteriologist in the meantime had been examining the water and reported that while he could not detect typhoid bacilli, it was his firm conviction that the water was responsible for the outbreak. The latter part of this statement was undoubtedly prompted by his knowledge of the extreme difficulty of detecting typhoid bacilli except when present in large numbers. His opinion was ridiculed somewhat and the owner of the water company again insisted that the water was all right.

Very naturally, many people ignored the order and injunctions of the bureau of health, saying that if the owner could drink the water with impunity it could certainly do them no harm. One case, perhaps, will answer for many. A supposedly intelligent friend of the writer, upon inquiry, said

No, we are not boiling the water at our house. We drank boiled water for one day and did not like it. Since then we have been drinking the water as it comes from the faucet. If Mr. ——— (the owner) can drink the water without harm, I think we can drink it safely.

There is no doubt in the mind of the writer that the owner of the water company, through his insisting that the water was pure, is directly responsible for a large number of cases.

The failure of many people to comply with the recommendations of the board of health soon became apparent in the alarming increase in the number of cases, about one thousand cases (nearly 1% of the population) being reported within one month after the report of the first case. This alarming increase in the number of cases caused the city authorities to appeal to the State Board of Health, and a physician and a sanitary engineer soon appeared on the scene. They first approved and emphasized the directions of the local board of health and then started an investigation of the drainage area and other possible sources of infection.

After a careful examination the state experts reported that the water from the three reservoirs previously referred to was badly polluted and was found to contain not only typhoid bacilli, but also other disease germs in dangerous quantities. The public was warned against taking the water into the system in any way except after boiling for at least thirty minutes.

They also reported, what to a certain extent has been common knowledge since the outbreak of the epidemic, that the sewage of many houses runs directly into the brook supplying the reservoirs; that overflow pipes from cesspools run to the brook; that out-door privies are close to the edge of the brook; that compost and garbage piles are in many cases so close to the brook that a single rain washes the entire pile into the water; that railroad and highway bridges cross the brooks close to the reservoirs; that railroads (one an important main line) follow the banks of the streams and the shores of two of the reservoirs, all the droppings from the trains being washed by rains directly into the water. It seems to be the general opinion among those competent to judge that filtration should have been resorted to long ago and should be adopted as soon as possible.

The writer feels compelled to interpolate at this time a favorite statement of an eminent professor of civil engineering under whom he studied: "A great drawback to the civil engineering profession is the fact that the structures that ought to fall down, don't." In view of the statement made in the preceeding paragraph, the writer thinks this might well be made to have special significance by changing it to read: "A great drawback to water supply engineering is the fact that water supplies that ought to cause epidemics of disease, don't." Certainly, in the case under discussion, the failure to have an epidemic before this can undoubtedly be attributed to the grace of God rather than to good engineering.

How far does the responsibility of the engineer in charge extend? It can probably be accepted as a fact that he was acquainted with the conditions that undoubtedly caused the epidemic. It can also be safely assumed that he is at least reasonably familiar with the mass of literature tending to prove that similar conditions elsewhere have been the cause of frightful epidemics and loss of life. This being the case, he had every reason to expect an epidemic; in fact, it does not seem too strong a statement to say that he should have known that an epidemic would certainly come sooner or later. It was his apparent duty to impress upon the owner the possible evil results that would follow such conditions and to urge the adoption of the most modern preventive measures, whether this meant the expenditure of money to remove sources of pollution from the drainage area or the installation of a filtration system.

Lack of funds cannot be offered as an excuse for failure, in the present case, to take proper preventive measures, for the water company has been highly successful from a financial standpoint. The writer has heard it stated frequently that the franchise of the company regulates the dividends. On this account there is an excess of earnings each year, and for several years this excess has been expended in building pleasure drives to and around the reservoir nearest the city. To how much better purpose this money could have been spent is indicated by present conditions.

Is not a sanitary or hydraulic engineer who does not know the condition of his drainage area negligent? Is not an engineer who does not know the evil results that can be expected to follow such conditions incompetent, and is not one who is acquainted with the conditions and probably certain results, and allows conditions to remain the same, morally and ethically criminal, if not legally so?

It is hard to find strictly analogous cases, but there are cases not entirely unlike in other lines. A mechanical engineer, with a proper sense of the ethics of his profession, would not be expected to retain for long his connection with a firm which built boilers, not according to the principles that experience and study have shown him to be safe, but, out of false economy, in a manner that rendered probable their early failure with possible loss of life. It seems to the writer that the engineer could not escape responsibility if he retained his connection with such a company. A bridge engineer with a proper sense of ethics of his profession would not be expected to retain for long his connection with a bridge company which insisted on building bridges of insufficient strength, or on building them in a manner that has been shown in the past to be dangerous; and that should convince him of the possibility of loss of life. If he retained his connection with a company indulging in such practices he would be morally and ethically responsible for any loss of life resulting from failures of such bridges. A structural engineer would not be expected to use a live load of 75 lbs. per sq. ft. in the design of a warehouse that would be subjected to many times that load. The failure or collapse that he would have every right to expect would compel him to resign before giving even his tacit approval to such plans. Would a reputable physician maintain his connection with a hospital in which malpractice was prevalent, or would he not rather sever his connection with it and inform the public of the facts? Aside from the legal aspect of this case he could not ethically retain his connection with such an enterprise.

Then what is the relation of the water supply engineer to the people? Is it not his duty, if he knows that conditions are such as have been proven dangerous, and finds it impossible to make the company or the municipality take proper preventive measures, to sever his connection with the company and inform the public of the facts? If he retained his connection with the company, would he not be guilty of engineering malpractice from a moral and ethical standpoint? On account of the peculiarly insidious nature of the danger against which he should be on his guard his responsibility is not so readily apparent as that of a mechanical, bridge or structural engineer, or of a physician, but is he not responsible, nevertheless? The writer would like to see this matter impartially discussed in your columns, as it may be the indirect cause of bringing about changes for the better in places where conditions are similar to those outlined above.

"Inquirer."

Washington, D. C., Jan. 12, 1907.

[The general question of the responsibility of purveyors of water and of water-works engineers for typhoid epidemics due to sewage and kindred water pollution is a very proper one for discussion. It should be remembered that in the case probably referred to by our correspondent all the evidence is not in. As to the general proposition, it should be noted that comparatively few water companies or municipal water boards in the United States have yet come to a realizing sense of the dangers of unfiltered surface water supplies, and fewer still have attempted to place them under rigid, intelligent sanitary supervision. This excuses no one from responsibility for the typhoid epidemics that do occur as a consequence, except in so far as any one is excusable for acting with an ignorant or indifferent majority instead of the intellectually and morally alert and progressive minority. It is in any case a nice question whether an engineer is called upon to make himself a martyr by sacrificing his position because his employer, public or private, does not act upon his advice. Ultimately, we have no doubt, engineers would resign their positions rather than be partners (if only through silence, as regards the public) to the purveying of polluted water. To-day, in the dense sanitary ignorance of many of our cities, an engineer who resigned for the reasons stated would be more like to be regarded as a fool than as a martyr—more's the pity!—Ed.]

Notes and Queries.

In the article on "Reinforced Concrete Caissons and Dock Walls at Rotterdam," in our issue of Jan. 17 (pp. 64 and 65) the title to Figs. 1 and 2 were accidentally transposed. The second cut (p. 65) shows the hollow

concrete caisson work, while the first cut (p. 64) shows the dock wall of reinforced concrete.

C. M. P., Sacramento, Cal., inquires for any court decisions bearing on the right of a retiring county surveyor to take with him from the office the field notes of surveys and engineering work which he has done for the county during his term of office.

THE 48-STORY TOWER OF THE METROPOLITAN LIFE BUILDING, NEW YORK CITY.

In our issue of Jan. 10, 1907, we published a short description and a photograph from a model of the tower now being erected as an addition to the Metropolitan Life Building at Madison Square, New York City. The structural features of the steel skeleton for the tallest office building yet undertaken are, of course, a matter of great interest to engineers. In this instance the designing engineers have introduced no very unique methods, in fact the design is remarkable in that it shows the availability of the ordinary system of skeleton construction even to such an enormous height.

For the first 11 stories—that is, to the same height as the existing building, the addition covers an area of 153 ft. by 75 ft. The tower proper above this level is 75 ft. by 85 ft. in plan. The entire structure rises to a total height of 658 ft. with 48 stories in all.

The general system of framing is shown diagramatically in Fig. 1. The whole skeleton is carried on 12 wall and 8 interior columns, which foot on cast-steel bases and I-beam grillages of varying sizes, reaching down to solid rock. The base for the largest corner column, shown in Fig. 3, is 7.5 ft. sq. and 3 ft. high and the grillage upon which it rests is made up of one tier of 20-in. I-beams and three tiers of 24-in. I-beams, 12 ft. square at the bottom. All these grillages are encased in concrete. The corner columns are made up with a double-cross section, the largest one weighing about a ton per lineal foot, with a section of 544 sq. ins. The intermediate columns are generally of a triple-web box section. An entasis of 8 and 12 ins. on the smaller and larger sides, respectively, of the tower is provided for by building the entire height of column on the same center line and diminishing the size of the columns as the upper stories are reached.

To the double wings of the wall columns are connected two parallel horizontal wall girders which perform the double duty of wind bracing and floor beam support. Below the 11th story both girders are of built-up section, but above

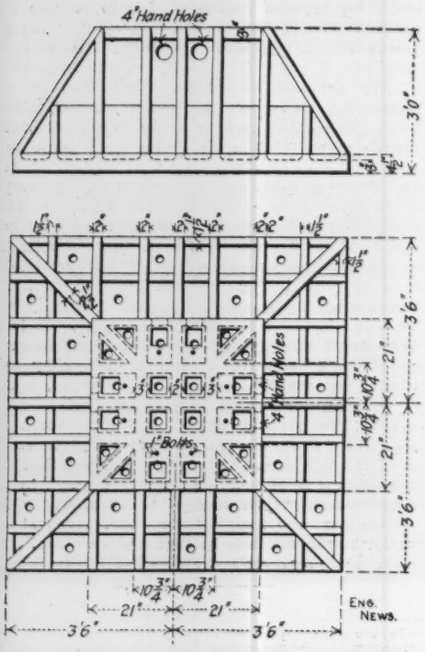


Fig. 3. Cast-Steel Shoe for Column Grillages for Tower, Metropolitan Life Building.

that point the inside girder, which carries the I-beam floor-beam, is changed to an I-beam.

In addition to the above horizontal wind brace girders, additional bracing is provided by double channels bracketed between the columns and the floor beams at the wall columns and by gusset plates at the inside columns. These knee braces are connected to the triple web of the interior columns and the double wings of the wall columns as shown in Fig. 4. A sway bracing of 6 x ⅜-in. plates is riveted every four stories across the top of the floorbeams.

At the 32d story a loggia floor prevents the use of the system of knee bracing provided for the lower floors. In order to stiffen the structure here and to carry the wind stresses past this point a heavy truss system (Fig. 2) built in the X-form shown, in order to avoid the window openings, is introduced in the vertical wall plane. This is tied back into the upper part of the structure by I-beams encased in concrete at the 35th story.

The system of columns, for the most part, is carried continuously to the 35th story, above which point the light tower columns start. This pyramidal tower construction is very light and extremely simple, consisting of double channel columns tied together with I-beam floorbeams and ¾-in. round tie-rods.

The architects of the building are Messrs. N. Le Brun & Sons, and the structural engineers are Messrs. Purdy & Henderson. We are indebted to the latter for the drawings herewith reproduced.

THE STEAMING OF TIMBER BEFORE TREATING WITH PRESERVATIVE.*

THE EVOLUTION OF THE STEAMING PROCESS.

By OCTAVE CHANUTE,† M. Am. Soc. C. E.

The original method of applying antiseptics for the preservation of wood was by soaking it in solutions, chiefly those of mineral salts, and that was the way in which ship timber for the "wooden walls of England" was treated with fair results over a century ago. With the opening of the railway era, more expeditious methods were called for. Breant, a Frenchman, in 1831, was the first to force antiseptics into wood with hydraulic pressure. He used a closed, vertical cylinder in which the wood was placed on end and pressure was applied with a pump. He indicated, moreover, that better penetration might be obtained by producing a partial vacuum in the cylinder before the admission of the antiseptics. Those which he employed were sulphate of iron, linseed oil and a mixture of linseed oil and resin. Burnett patented the injection of chloride of zinc in 1838; he first employed the soaking method, but subsequently he used pressure in closed cylinders. Bethel, in the same year, patented the use of creosote and used the Breant method, but his cylinder was horizontal and he produced a partial vacuum therein before admitting the creosote. His apparatus and his methods were substantially the modern ones and have continued in use to this day, but some difficulties were found when operating upon any but thoroughly seasoned timber, and in 1846 Pain introduced the process of previous steaming. His method for the injection of sulphate of iron and sulphate of barium consisted in, first, steaming for 15 mins., then applying a vacuum for 10 mins., then introducing the antiseptic, and finally applying a pressure of 8 to 10 atmospheres, continued 40 to 50 mins. This was thought to be a notable improvement, more especially when operating upon imperfectly or half seasoned timber, and it rapidly grew in favor.

In 1857, Messrs. Lege and Fleury-Pironnett patented an apparatus for injecting railway ties with sulphate of copper by the steaming-vacuum-pressure process and tried a great many intelligent experiments upon fresh cut, half seasoned and fully seasoned wood of various species, to establish the exact advantage of each step in the process. A commission to examine these results, appointed by the Agricultural Society of Sarte (a French Department) tried further experiments and thus summed up the ascertained advantages of steaming:

Wood, in seasoning, loses a good deal of weight and yet shrinks but little, the sap-ducts lose the evaporated water and their walls become incrusted with the non-volatile portions of the sap, among which is vegetable albumen, constituting the principal cause of decay. The albumen, dried at ordinary temperature, hardens into a horn-like substance, but the application of moisture and gentle heat again dissolves it and thus re-establishes the continuity of the sap-ducts. It is important to reach this result with the least possible amount of condensed water, so as to leave as many voids as practicable to be permeated by the antiseptic solution. This is best accomplished by steaming at temperatures from 212° to 240° F. for ten minutes to three hours, according to the kind and

*Two papers read before the Wood Preservers' Association at its annual meeting at Memphis, Tenn., Jan. 16, 1907.

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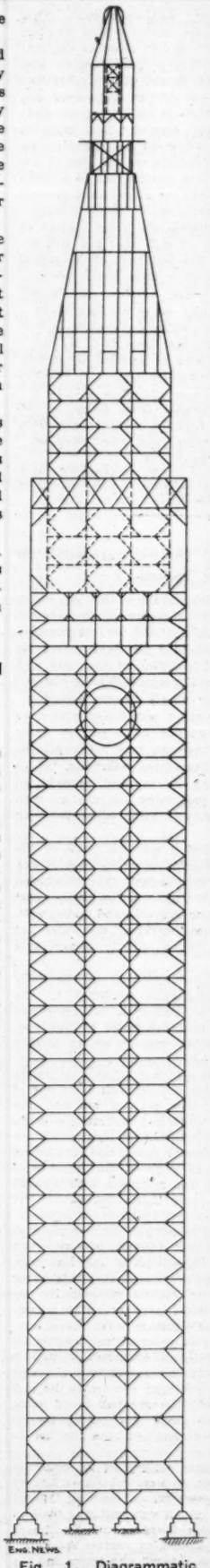

Fig. 1. Diagrammatic Elevation of the Steel Skeleton for the 48-Story Tower Addition to the Metropolitan Life Building, Madison Square, New York City.

condition of the w... by following thi... some ten minutes ... great a vacuum as ... The steam penetr... dampens all the ... the wood; it h... swells it conside... carries off, moreo... sort of washing ... volatile or solu... stances, and yet it ... in the wood in su... quantities that the ... in weight is negli... sometimes is mo... overbalanced by th... of matters extracte...

This, it should b... was predicated upo... injection of sulphate o...

It is believed that ... ing before the vacu... was then universally ad... in Europe by all the es... ments which injected ... eral salts, but th... jecting creosote early ... nized that the small ... unt of condensed steam ... in the wood resisted to ... me extent the injection of this oily substance and the writer believes that the present practice in Europe is not to steam wood intended to be creosoted. In England, the timber, much of which has been rafted is very thoroughly air seasoned. In France and Germany ties are stacked in open piles for ten or twelve months, during which time some 16 to 25% of the weight is lost, and then they are in many cases desiccated further in drying ovens (not dry kilns), during which latter process they lose 3 or 4% more of weight before being transferred warm into the creosoting cylinder. Another method is to boil the ties in hot creosote so as to evaporate the sap and make room for the creosote which is injected by pressure. This is, perhaps, the best method, laboratory experiments showing that there is still 18 to 20% of moisture in so-called "thoroughly air-seasoned" timber. For wood to be injected with mineral salts, steaming is generally resorted to in Europe. These salts being in watery solutions, condensed steam is not objectionable as it merely weakens the solution, which is made a trifle stronger than would otherwise be the case.

In the United States, Hayford took out various patents for steaming in 1859, 1870, 1872 and 1877, which were hailed as great improvements and went into extensive use even for creosoting. For a time every wood-preserver steamed before injection and it is only within the last two or three years that the question has been raised whether better penetration with mineral salts cannot be obtained by omitting steaming altogether.

The writer, having tried hundreds of experiments during the first ten or fifteen years of his practice in the injection of mineral salts, believes that the question whether or not it is advisable to steam depends altogether upon the condition of the wood when it becomes necessary to inject it. The best practice is to ... son it thoroughly, but ...

tomers are generally impatient and urgently require the treated wood for immediate use. So the operator has often the alternative of either discommoding his client or, of not doing the best work of which he is capable. He not infrequently unloads timber on the ground at his own expense in order to season it a little more.

The structure generally contains 30 to 50% of cells by volume. In the living trees, these cells are filled with sap and the problem is how to replace this sap with some preservative substance. In rafting, a small part is washed out by diffusion and in air seasoning perhaps over one-half of the watery portion of the sap slowly evaporates. It is obvious enough that in order to inject satisfactory amounts of any antiseptic, a place for this must be found in the wood and if the sap cells be filled with sap or water it is clearly impossible to fill them with another fluid. To clear the sap cells, therefore, we must produce some motive force inside the wood. This motive power may consist of steam generated inside of the wood, or it may consist of air which has replaced so much of the watery portion of the sap as has evaporated in seasoning, which air is heated and expanded by steaming.

Proceeding upon this theory, the writer tried very many experiments with various species of wood, fresh cut, quarter seasoned, half seasoned or wholly seasoned, by steaming them various lengths of time, they being weighed in and out at each stage of the operations. He found that where the wood was fresh cut and full of watery sap, it required no less than eight hours of steaming at 20 lbs. pressure (258° F.) to bring the center of a tie 6 x 8 ins. in section to the boiling point (212° F.), at which the sap would begin to generate steam so as to drive out some of the watery portion. It is understood that the creosoters who operate upon fresh cut or waterlogged piles are sometimes compelled to steam for twenty-four hours, at more than 20 lbs. pressure, in order to clear the wood for injection. In that case, it is probably safe to begin the operation with steam as high as 30 lbs. pressure (275° F.) because the water in the wood which first evaporates protects the fiber from immediate injury; but towards the close of the operation the pressure should not exceed 20 lbs., which has been found the point (258° F.) at which small injury to the strength of the fiber is likely to result.

With half-seasoned ties, i. e., air-dried from four to six months, according to the time of the year, the writer ascertained the perhaps surprising fact that more sap could be extracted by one to three hours' steaming than could be got out of fresh cut ties by three to five hours of steaming, at 20 lbs. pressure. Of course there was more of the watery portions of the sap in the fresh cut ties than in those half seasoned, but it could not be extracted satisfactorily without much longer steaming. It was concluded that when the wood was half seasoned some air had flowed in and that this, being moderately heated by the steaming, expanded so as to drive out a good deal of the remaining sap and this view was confirmed by the examination of the ties immediately upon their withdrawal from the treating cylinder, when minute bubbles of air and sap were observed issuing from the ends of the ties.

With fully seasoned ties, say six to twelve months from the cutting, the effect of the steaming was sometimes to increase the weight of the ties, and sometimes to diminish it, such increase or loss being, however, very small (well within 2%). It was found that when the ties were in that condition, it was best to dispense with the steaming altogether and to begin with the vacuum, as more solution (chloride of zinc in this case) could be injected than when the ties were previously steamed, which latter operation, leaving some condensed steam in the wood

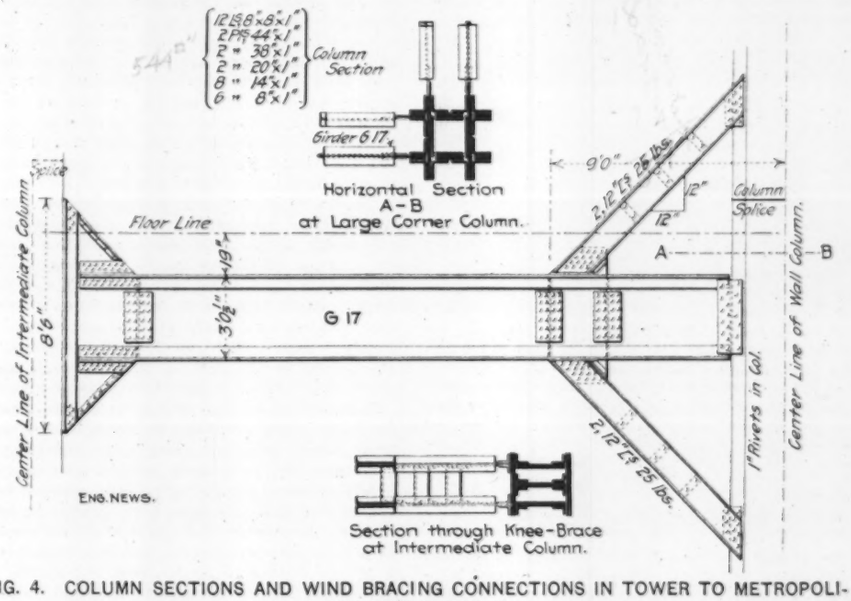

FIG. 4. COLUMN SECTIONS AND WIND BRACING CONNECTIONS IN TOWER TO METROPOLITAN LIFE BUILDING.

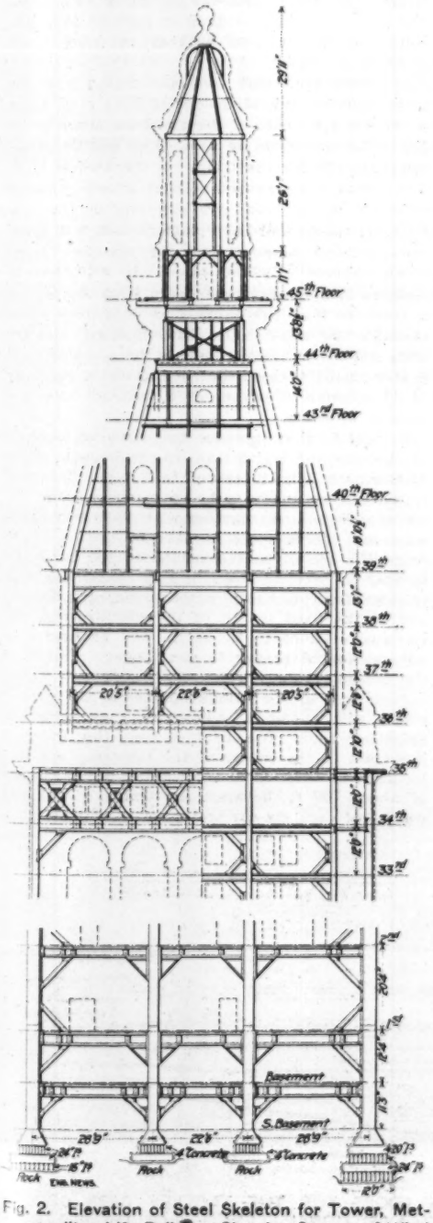

Fig. 2. Elevation of Steel Skeleton for Tower, Metropolitan Life Building, Showing System of Wind Bracing and Column Grillages.

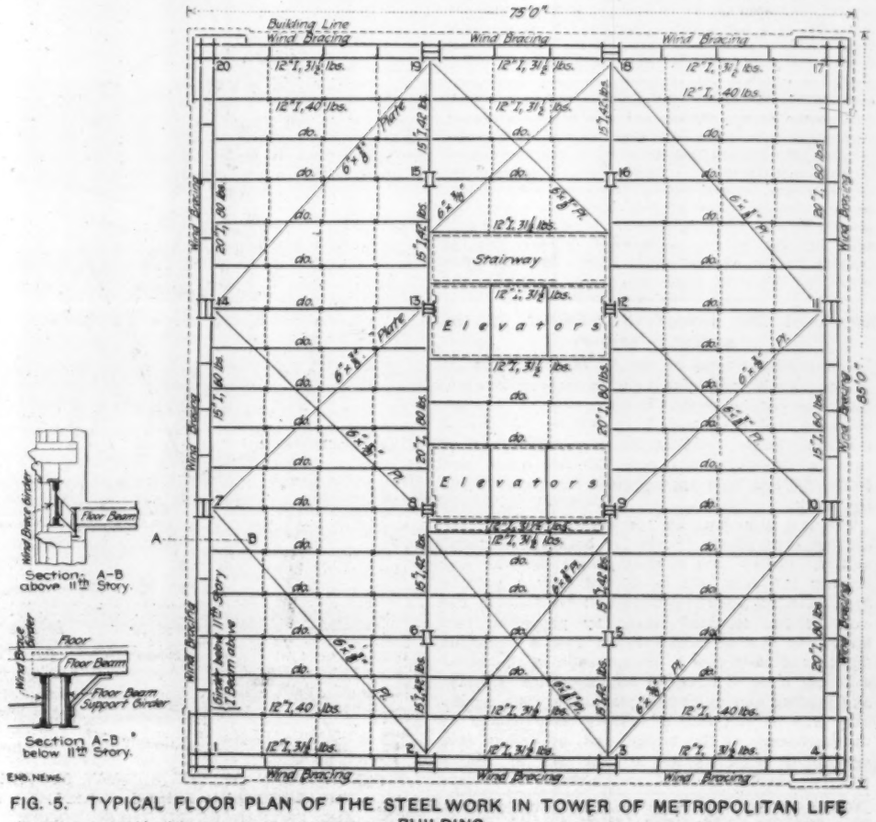

FIG. 5. TYPICAL FLOOR PLAN OF THE STEELWORK IN TOWER OF METROPOLITAN LIFE BUILDING.

(say perhaps 5% of its weight, reduced to 2% by the subsequent vacuum) diminished by just so much the quantity of solution which could be forced into the tie. These experiments were made from 1890 to 1900 and were fully confirmed by experiments made in 1904 by Mr. S. M. Rowe.

From these results and from experience gained in regular working, the following practice has grown up at the works of the writer:

(1) To refuse to treat fresh cut ties, but to put them down on the ground to season.

(2) To begin the spring season's treating by steaming, unless the ties are of the previous year's cutting.

(3) To omit steaming in the summer and autumn when the ties prove to be well seasoned.

This practice leaves open the question whether it is important for the best results to first sterilize the germs of decay by heat, either that of steam or that of hot air by drying ovens. Some bacteriologists hold that the germs of decay exist in the sap of the wood before it is cut down and some believe that these germs penetrate into the wood after it is treated. The writer's experience is not sufficient to enable him to adduce any facts bearing on this question, but he believes that the European practice of heating wood in drying ovens just prior to its injection is good, and that this may be the next improvement which should be introduced in this country.

AIR-SEASONING VS. STEAMING.

By DAVID ALLERTON.*

In treating air-seasoned wood, steaming is not only unnecessary, but a positive disadvantage, as wood is injured to a greater or lesser extent by steaming, depending upon the variety, the temperature and the duration of the process. To treat seasoned timber without steaming, the cylinders must contain steam pipes to keep the solution hot and bring the wood up to the same temperature, and the pressure must be very gradual; if this process is followed, the impregnation will be as thorough as if the wood was steamed and there will be no subsequent drip.

It is often necessary to treat timber when green if it is to be treated at all, and it seems to be necessary to steam such timber, in order to extract the surplus water, to soften the wood and permit the necessary amount of solution to be injected. This artificial seasoning, it is very evident, cannot take the place of air seasoning, as it has to be done in a short space of time and in a temperature very much greater than in any natural process.

Every one has noticed the checking of wood in the process of seasoning; at the ends of a log, for instance, the cracks are very noticeable, as the water has evaporated through the capillaries quite rapidly and the shrinkage due to drying has caused the fibers to part at various places where there is the least adhesion. On the sides of the log, the same process takes place, but is much slower; the season checks, as they are called, develop the same, but in a less degree. The moisture in the wood must evaporate from the outside and the fibers contract as they are dried, the outer ones being dry, while those inside are still wet and expanded; the outer fibers contracting over the inside ones naturally become ruptured, causing the season checks, and this process gradually takes place to the center of the log, but this being harder (heart wood) contains less moisture, so that the process is slower and the ruptures not apparent. It seems to me that this slow, natural process leaves the wood in better condition for treatment than a steaming process can possibly do and that it is necessary to be very careful to avoid injuring the wood so steamed. I know that the Douglas fir can be very much injured by what some would call "moderate steaming."

*Superintendent, Oregon Railroad & Navigation Co.'s wood-preserving works, Wyeth, Oregon.

ENLARGING THE MANHATTAN TERMINAL OF THE BROOKLYN BRIDGE.

The reconstruction of the Manhattan terminal of the Brooklyn Bridge to give increased traffic facilities and to permit the running of through elevated trains to and from Manhattan during the rush hours, without the present change of cars in Brooklyn, has been decided upon, and $3,250,000 has been appropriated for carrying out the work.

The end aimed at by the designers is the rearrangement of the tracks for both the elevated and the trolley cars so that people entering and leaving the cars will be spread over a greater area than at present. This will be done in the case of the elevated trains by providing two levels for the terminal tracks and a sufficient number of platforms to permit each of the seven different lines to have its own separate terminal and loading and unloading platforms. The trolley cars will be run into a subway commencing at the anchorage of the bridge, and, by means of a system of loops similar to that now in use, it will be possible to load and unload these cars without in any way interfering with the elevated passenger traffic.

Fig. 1 shows a plan of the subway system of loops for the trolley cars; also a sectional elevation of the platforms and entrances to these loops. As previously stated, the incline of the subway will commence at the anchorage of the bridge, and the grade will be such that at about 300 ft. inward from this point the cars will be wholly under the bridge roadway.

To permit of the subway arrangement for the trolley cars without cutting the masonry of the bridge arches, the roadways, after leaving the confines of the bridge, will be widened and the tracks carried on the outside of the roadways. North William St. will have to be closed and William St. lowered to pass beneath the trolley tracks. The trolley tracks will also cut off the top of the arch at Rose St., but not so much as to affect the necessary street clearance.

Passengers for the trolley cars will descend from the street by means of stairs leading down from three entrances, and upon reaching the mezzanine floor will again descend another staircase leading to the particular loop around which passes the line of cars they desire to enter. Though the number of loops will be the same as at present, namely, eight, it will be impossible for a person seeking a car to cross the tracks, and by means of two staircases for each loop the incoming and outgoing passengers will also be effectually separated.

The arrangement for the elevated cars is shown in plan and elevation in Fig. 2. There will be four tracks on each of two levels, two platforms per track, and the tracks will come together at Pearl St. The upper of these levels will occupy the same place as the present elevated level, and the lower level will occupy practically the same space now taken by the present mezzanine floor. The present mezzanine floor will be lowered to give sufficient head room; this can be done, because the trolley cars will be removed from the surface beneath the mezzanine floor and the passengers going to the promenade can begin to make the ascent after having passed the easterly end of the station overhead.

Access to the bridge trains under present conditions is very inconvenient. The incom... and outgoing passengers are not separated, ... are led forward by a number of narrow sta... ...ys and more or less confusing passages. Un... the new plans, passengers for the elevated tra... will ascend from the westerly side of Park ... a broad flight of steps, and will cross a brid... ...ver Park Row having a width of about 67 ft.

After crossing the bridge, passengers d... ...ing to enter the trains at the lower level will p... ...ed straightonward, and those going to the tr... ...on the upper level will ascend by either o... ...wo staircases, each 20 ft. in width, to the ... ...per level. After passing a row of ticket ... ...es located at the entrance to the platforms in... ...ach of the two levels, the outgoing passenger... ...ill proceed straight to the loading platform... ...of which there are two at each level. It w... ...be seen from this description, taken in conn... ...ion with Fig. 2, that the outgoing passengers ... ...ove in straight lines without turns and by the ...hort-est possible routes.

Incoming passengers on the elevated trains will walk along the unloading platforms, those desiring to proceed in a northerly direction passing down stairs located on the easterly side of Park Row and directly north of the bridge. Those desiring to go in a southerly direction will pass down similar stairs on the south side of the bridge. In both cases the incoming passengers will proceed without coming in contact with outgoing passengers and without reversing their direction of travel.

As there are eight terminal tracks and but seven different elevated lines to be served, there is one track for each of them and one spare track. The extra track will be used as an additional accommodation for the trains on the busiest lines. The tracks are arranged so that a train entering either level can run into any one of the four terminal tracks and have platforms on both sides, the platform arrangements of the two levels being substantially the same. It will thus be possible to discharge passengers from one side of a train and at the same time load passengers through the other side. This change, together with the other improvements here noted, will enable trains to be dispatched under a headway of 45 seconds, a saving of 10 seconds over the present schedule.

To still further increase the carrying capacity of the elevated trains, the length of each of the platforms will be increased to 320 ft. This will enable six-car trains to be operated on all of the elevated lines, and, together with the closer headway, will increase the number of cars per hour from 325, the present schedule, to 480 per hour. It may be well to state in this connection that the elevated trains are limited to six cars, by reason of the fixed length of the platforms at the elevated stations in Brooklyn, and because it is not considered proper to run longer trains over the present bridge structure.

According to the bridge engineers, the six-car trains will be run at a speed not exceeding 15 miles per hour. The distance from the center of one train to the center of the following one will be not less than 1,000 ft., leaving a clear space of about 700 ft. between the trains. The total weight of each six-car train, which will be made

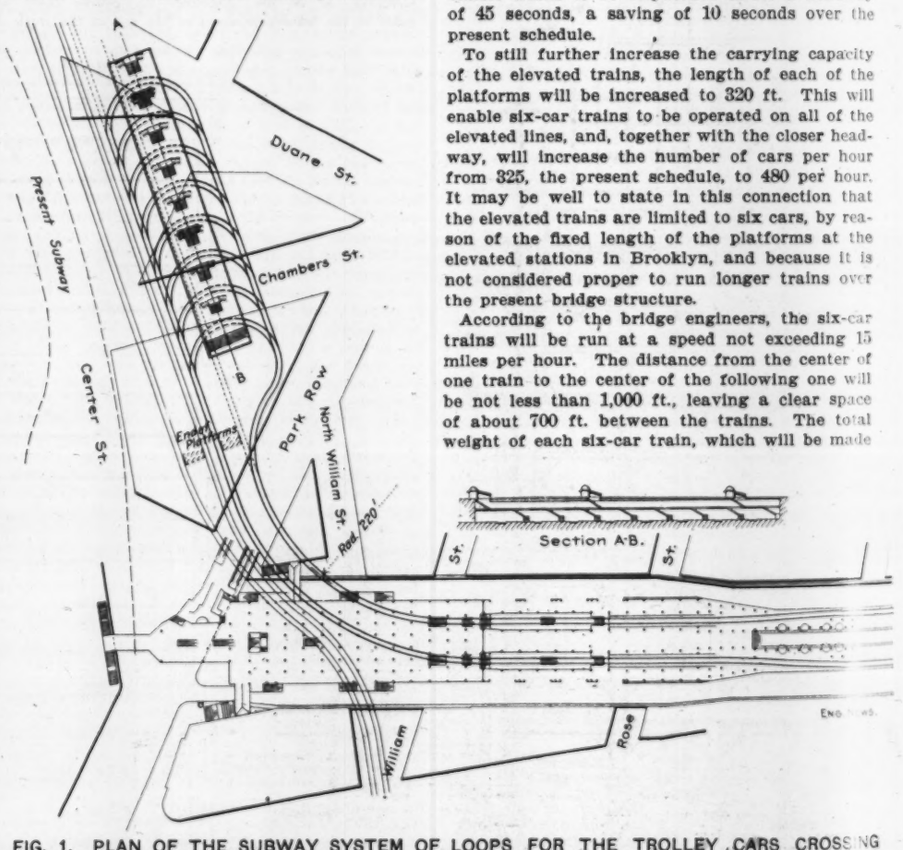

FIG. 1. PLAN OF THE SUBWAY SYSTEM OF LOOPS FOR THE TROLLEY CARS CROSSING THE BROOKLYN BRIDGE, TOGETHER WITH A SECTIONAL ELEVATION OF THE PLATFORMS AND ENTRANCES TO THESE LOOPS.

up of four motor cars and two trailers, will, when fully loaded, be 472,000 lbs., and the distance between centers of any two successive trolley cars will not be less than 100 ft.

Assuming these loading conditions have each their maximum permissible value and allowing for the usual vehicle and foot traffic, the greatest possible stress in the wires of the bridge cables has been found by the engineers to be not over 53,000 lbs. per sq. in., while under ordinary working conditions the stress would not exceed 46,300 lbs. per sq. in. In comparison with the ultimate carrying capacity of these cables, determined by actual test when the bridge was constructed, these maximum stresses will load them from about one-third to about one-quarter of their ultimate carrying capacity.

With the same conditions of maximum or congested loading, the maximum stresses in the members of the stiffening trusses might reach 24,000 lbs. per sq. in. According to the original records and the results of later tests, the steel in the stiffening trusses has an ultimate tensile resistance of approximately 90,000 lbs. per sq. in., with an elastic limit not far from two-thirds of that value. It is thus seen that the metal of the stiffening trusses will never be subjected to more than one-third to a little over one-fourth of its ultimate resistance.

The stresses in the masonry of the towers would be increased so little by the extra car per train that the carrying capacity and stability of the towers would not be sensibly affected, and the anchor bars connecting the extremities of the cables to the anchorage masonry would not be subjected to a stress over 13,800 lbs. per. sq. in., which is perfectly safe for these members. The flooring, however, requires reconstructing, and this is now being done. When this work is completed the entire bridge will be able to sustain and carry indefinitely the maximum traffic which will be placed upon it under the new conditions.

For maintaining the proper distance between trains, not only for safety in the operation of the cars, but also that there may not be such a congestion of trains as to produce greater stresses in the members of the bridge than those previously mentioned, the entire structure will be completely fitted with a modern and effective system of signals.

It is interesting to note in this connection that the computations made by the bridge engineers show there will be less liability to derangement of the saddles at the tops of the towers, and, in turn, less derangement of the suspenders and diagonals in the stiffening trusses, under the proposed operation of six-car trains with fixed spacing, than under the present traffic conditions, with irregular and often very short spacing.

As the reconstruction of the Manhattan terminus of the bridge along the lines here described will require about 2½ years, it is intended to provide immediate partial relief by extending the present tail-tracks of the elevated lines 60 ft. westerly over Park Row. This will enable six cars to be used in every train, and the necessary work to be done for this extension should not require over six months. The work will not be expensive, and this temporary makeshift will remain only during the reconstruction of the Manhattan terminus. Upon the completion of the new station this addition will be removed, as it will then be of no practical use.

The improvements noted in this article will not in any way postpone or obviate the necessity of running trains through Manhattan connecting the East River bridges. In fact, it was decided on Jan. 25 to connect the Manhattan terminals of the Brooklyn and Williamsburg bridges by a four-track subway, which can be built in 2½ years at a cost of $5,245,000. In case the trolley tracks run through, it will only be necessary to connect the subway with the northerly end of the trolley station. If the elevated cars are to be run through, the trolley cars will be placed upon the lower elevated level and the elevated trains will then run on the trolley tracks in the subway.

PROGRESS IN CLOSING THE BREAK OF THE COLORADO RIVER.

[By a Special Correspondent.]

[The interesting events connected with the break in the Colorado River were reviewed at length in our issue of Dec. 27. The final closure there chronicled by Mr. H. T. Corey proved to be but temporary, as was stated in an editorial note accompanying his article. Later events have been recorded in our issues of Jan. 3, p. 15, and Jan. 17, pp. 69, 76, and are summarized by our correspondent as follows:—Ed.]

The break in the river, following the closure, occurred about Dec. 7 or 8. President Roosevelt's attention was called to the matter by telegrams from California a week later. He at once began correspondence by telegraph with Mr. E. H. Harriman, President of the Southern Pacific Co., and on Dec. 20 asked Mr. Harriman to close the break, temporarily at least, until the matter could be brought to the attention of Congress. Mr. Harriman has responded by making plans to close the break, with the understanding that after the break is closed the work will be taken off his hands by the Government.

On Jan. 12, 1907, the President sent a message to Congress embodying these general facts. On the same day Senator Flint introduced a bill in the Senate, and about the same time Mr. Lacey introduced a bill in the House. Senator Flint's bill has been reported to the Senate, appropriating $2,000,000 to make a closure of the break and to get the money back through the creation of a Reclamation Service project in the valley. Mr. Lacey's bill was reported by the House Committee on Public Lands, for the amount of $1,500,000, without any provision for obtaining the return of this money from the persons benefited.

Congress adjourns on March 4, and in the five weeks which remain before that date nearly all of the important work of the session must be transacted. Nearly all the large appropriation bills are yet to be considered and a very large amount of Federal legislation, so that the chance of passage of any one special bill of this kind is very remote.

If some bill is not passed to enable the Government to take charge of the break in the river in Mexico it is possible that Mr. Harriman may conclude not to close the break, but to abandon the underlying country to its fate, putting the railroad out of the reach of water around the Salton Sea. He has already loaned about $2,000,000 in cash to the California Development Co., and probably has other claims against the company for damages, directly or indirectly, to his road. The company is believed to be bankrupt; in fact, it is so stated by its treasurer. It has large outstanding obligations or liabilities to the settlers in the way of furnishing water, and a large cash investment must be made to put its work in such condition as to insure a permanent water supply to the valley.

A telegram from Yuma, Ariz., states that work was delayed for about four days by floods; that one trestle at Imperial heading had been completed and that rock would be dumped beginning about Jan. 26. If good conditions prevail the break can probably be closed in about 30 days. If, however, the river should rise and take out portions of the trestle the work might be delayed or prevented.

When the break is closed, however, the next difficulty will be to retain the long line of dikes which will guard the river from again breaking through near this point. The question from an engineering standpoint is not so much to close the river. This has already been done once and can be done again at an estimated cost of about $500,000. The principal difficulty is in permanently maintaining the dikes against the floods which will come in the early spring. The passage of the water under the dikes in the early part of December shows the treacherous character of the soil and illustrates the necessity of extreme care in constructing and maintaining the dikes.

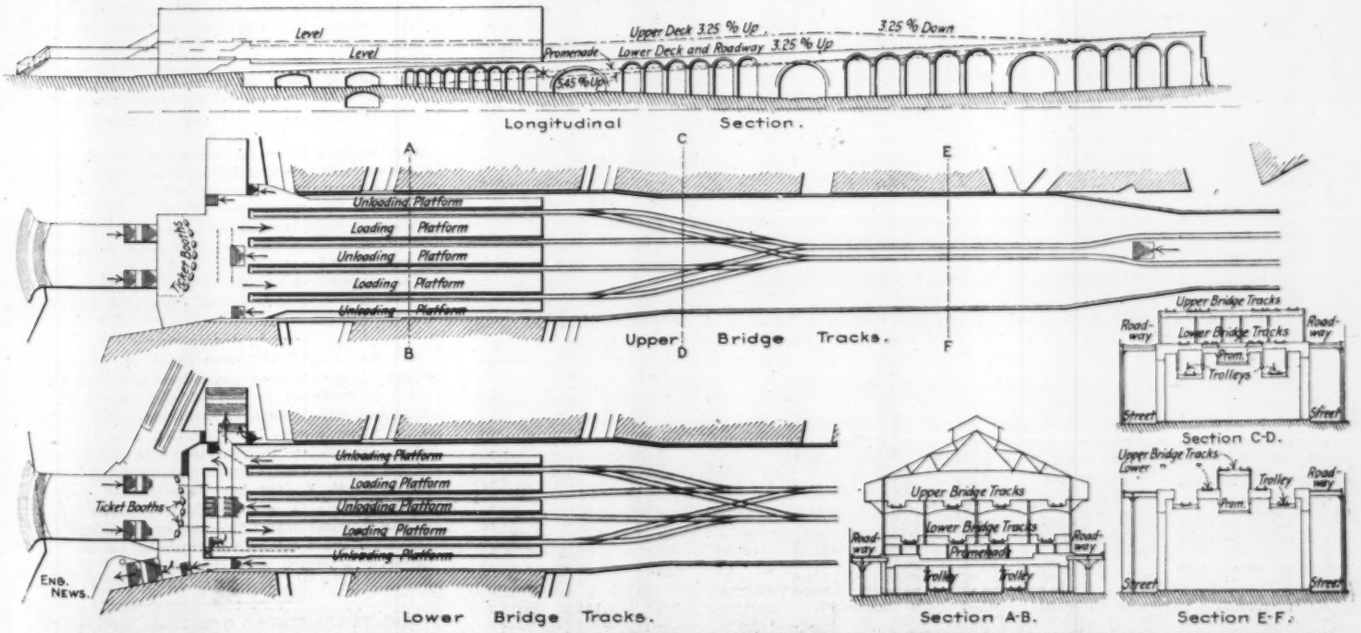

FIG. 2. THE TWO-PLATFORM ARRANGEMENT FOR THE ELEVATED CARS, PROVIDING EIGHT TERMINAL TRACKS WHICH WILL ENABLE SIX-CAR TRAINS TO BE RUN AND LOADED AND UNLOADED SIMULTANEOUSLY.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The thirteenth annual meeting of this society was held Jan. 22-24, 1907, in the United Engineering Building, 29 West 39th St., New York City. The attendance, including guests, was about 160. Although a number of interesting papers were read, the majority of them called forth little or no discussion. The "topics for discussion" in the program, with but one or two exceptions, met with a similar treatment.

This being the first annual meeting of any society to be held in the new Engineering Building, may rightly be said to have christened the building for such occasions. The heating of the room in which the meetings were held was very poor, and called forth a number of complaints. While the inadequacy of the heat, particularly on account of the extreme cold weather which prevailed at that time and the type of engineers who were assembled, was to be regretted, it must be remembered the heating plant of the building is not entirely completed and the weather was exceptionally cold for New York City.

The opening session was called to order Tuesday, Jan. 22, by the President, Mr. John Gormly, of Philadelphia, Pa.

The reports of the Secretary and Treasurer showed a total membership of 279, of which 36 had enrolled since the last meeting, and a balance on hand of $1,794.90.

The reports of Committees on Tests were then presented. Prof. R. C. Carpenter, of Cornell University, gave results obtained in insulation tests of radiators of different makes. These tests were conducted on 10-in. pipes surrounded with wooden chip insulation, which in turn was inclosed by three thicknesses of 1-in. pine boards with tarred paper between the boards. The heat loss was found to be 20% per 1,000 ft. of transmission, and the coefficient of radiation 1.5 instead of the usually accepted 1.8.

For the report of the committee collecting data on hot-water heating systems, of which committee Mr. James Mackay, of Chicago, Ill., was the chairman, 200 inquiries were sent to manufacturers of cast-iron boilers for residence hot-water heating. The questions related to the boilers, the radiation and the piping. The formulated results secured are: The grate surface in square feet = the radiation in square feet, not including the piping, ÷ 189. It was found that the rating of boilers per square foot of grate surface varied greatly among different manufacturers.

The second session was held Tuesday evening. The first business transacted was the presentation of the report of the tellers, who announced the following officers elected: President, Mr. C. B. J. Snyder, of New York City; First Vice-President, Mr. James Mackay, of Chicago, Ill.; Second Vice-President, Mr. Wm. G. Snow, of Boston, Mass.; Secretary, Mr. Wm. M. Mackay, of New York; Treasurer, Mr. U. G. Scollay, of Brooklyn, N. Y.; Board of Governors, Prof. R. C. Carpenter, of Ithaca, N. Y.; Mr. Robt. E. Atkinson, of Leicester, Eng.; Mr. Frank K. Chew, of New York City; Mr. Edmund F. Capron, of Chicago, Ill., and Mr. Albert B. Franklin, of Boston, Mass.

Two papers were presented during the evening session, one by Mr. James A. Donnelly, on "Standard Sizes of Steam Mains," and the other by Prof. William Kent, on "The Carrying Capacity of Pipes in Low-Pressure Steam Heating." As Prof. Kent was kept away by illness, Prof. Carpenter read his paper to those present.

Both these papers were much alike, and the formulas contained in them for determining steam pipe sizes were almost identical, the value of the constant used being the only practical difference. According to Mr. Donnelly's paper:

> The maximum velocity permissible for all systems using fairly dry steam from 25 ins. of vacuum to 15 lbs. gage pressures should be that which would require not more than one ounce difference in pressure for 100 ft. run in straight pipe to maintain it. It is believed that this maximum velocity would give very good results for all plants with reasonably short runs, and as the length increased, the individual judgment of the engineer must be used to keep the total drop in pressure within the amount desired and available.
>
> The fact is of course recognized that there are some conditions and circumstances which would render it advisable to use a lower velocity, such as an unusual number of elbows, but it should be applicable as a maximum velocity to all ordinary cases and conditions.

Prof. Kent stated in his paper that in any case a pipe should be proportioned for the worst set of conditions which are likely to be met. In the ordinary small installation the probability of frequent bad conditions is very great. Ample grate surface and heating surface in boilers are generally provided and great care is taken to properly place the steam and return pipes so there is as little liability of obstruction to flow of steam or water as possible. Instead of basing his deductions on an assumed drop of pressure of 1 ounce per 100 ft., i. e., 1 lb. per 1,600 ft., as did Mr. Donnelly, Prof. Kent assumed the drop to be 1 lb. per 1,000 ft. of length. This, of course, makes a slight difference in the results obtained in the two cases. In the table below is given the flow of steam at low pressures obtained by Prof. Kent under the assumption he made.

Mr. R. P. Bolton, of New York City, said he believed that the formulas for determining steam pipe sizes should not be based on extreme weather conditions. For only about four days in a year does zero temperature obtain in New York City, said he, and at these times it occurs usually not in daytime, but at night. He spoke of complaints that had arisen from this cause, complaints that furnaces required more coal to give the necessary amount of heat in moderate weather than in cold weather. He said this was due to the pipes being of too large diameter, being designed for the extreme conditions, and thereby allowing the steam to remain in them rather than circulate and perform its duty. Mr. Bolton believed that in the near future slightly superheated steam would be used in the mains and branches of heating systems; this would enable smaller pipes to be used.

Mr. Wm. J. Baldwin spoke of the safe velocity of steam in vertical and horizontal pipes. In the former he claimed 30 ft. per sec. to be the safe limit, and in the latter 15 ft. per sec.

Mr. R. B. Talcott, of Washington, D. C., referred to tests made on vertical pipes ¼-in. to 2 ins. diameter that proved steam velocities up to 50 ft. per sec. allowed condensed steam to descend. He urged the use of comparatively small pipes, on account of the great loss due to condensation in large ones.

The Wednesday afternoon session was taken up chiefly with the reading of the two following papers, and the discussions on them. The discussions, however, were very brief, due largely to the mathematical nature of the papers.

The first paper, "Temperatures for Testing Indirect Heating Systems," by Mr. W. W. Macon, gave values of temperatures for use in testing indirect heating systems, steam as well as hot-water, during periods when the zero [illegible] conditions for which the system is desig[illegible] are not existing. The second paper, "The [illegible]va-tion of Our Constants for Building Loss[illegible] by Prof. R. C. Carpenter, described the prog[illegible] in apparatus for heating and ventilating pu[illegible]es, gave the coefficients to be applied to det[illegible]ine the transfer of heat through walls and wi[illegible]ws, and also the constants necessary for con[illegible]ng theoretical formulas into shape for practica[illegible]e.

The first paper on the list for Thursday [illegible]rn-ing was entitled "Comparison of Quick [illegible]u-lating Systems of Hot-Water Heating." [illegible]his paper was written by Mr. C. Guitton, [illegible] St. Etienne, France, and was read by Prof. [illegible] C. Carpenter. It called attention to the dif[illegible]nt methods employed in quick circulating [illegible]ot-water heating systems, and was passed wi[illegible] no discussion.

The next paper, "Systems of Heating Ra[illegible]way Cars with Hot Water," by Prof. R. C. Carp[illegible]er, created an animated discussion on the re[illegible]tive merits of steam and electricity for heating [illegible]ail-way cars, although the paper itself treated [illegible]nly of the steam heating side of the subject. The paper gave a bird's-eye view of the various [illegible]ail-way car heating systems which have been [illegible]sed. The hot-water plan is now in almost univ[illegible]sal use, although pressure systems employing live steam are also employed. Exhaust steam is now very rarely used for heating cars.

Mr. H. J. Barron, of New York City, thought that the heating and ventilating of railway cars would in the near future be done largely by means of electricity, particularly so in view of the recent moves toward the electrification of existing steam lines. Mr. Wm. J. Baldwin, however, claimed that it would cost more in severe weather to heat a train by electricity than it would to haul it.

Before final adjournment the place for holding the semi-annual meeting was discussed. Invitations were extended from Kansas City, Chicago, Kalamazoo, Milwaukee, Niagara Falls, and Atlantic City. Although a final decision on this matter was not reached before adjournment, the sentiment seemed to be in favor of Milwaukee.

FLOW OF STEAM AT LOW PRESSURES IN POUNDS PER MINUTE FOR A UNIFORM DROP AT THE RATE OF ONE POUND PER 1,000 FEET LENGTH OF STRAIGHT PIPE.

Nominal diam. of pipe, ins.	Steam pressures, by gage, at entrance of pipe. 0.3	1.3	2.3	3.3	4.3	5.3	6.3	8.3	10.3
	Flow of steam, pounds per minute.								
½	.070	.072	.074	.076	.078	.080	.082	.085	.089
¾	.161	.166	.171	.375	.180	.184	.188	.197	.205
1	.317	.328	.336	.345	.354	.362	.371	.387	.403
1¼	.668	.688	.708	.728	.746	.765	.782	.817	.849
1½	1.023	1.054	1.085	1.114	1.143	1.171	1.198	1.250	1.300
2	2.013	2.075	2.136	2.191	2.250	2.305	2.358	2.462	2.560
2½	3.261	3.363	3.459	3.553	3.645	3.734	3.820	3.987	4.147
3	5.758	5.935	6.108	6.274	6.435	6.592	6.745	7.040	7.321
3½	8.421	8.680	8.932	9.175	9.411	9.642	9.864	10.30	10.71
4	11.69	12.05	12.40	12.74	13.07	13.39	13.70	14.29	14.86
4½	15.64	16.13	16.59	17.05	17.48	17.91	18.33	19.13	19.89
5	20.87	21.51	22.14	22.74	23.32	23.89	24.45	25.52	26.54
6	33.52	34.56	35.56	36.53	37.46	38.38	39.27	40.99	42.62
7	48.94	50.45	51.91	53.32	54.69	56.03	57.33	59.83	62.22
8	68.04	70.14	72.18	74.14	76.04	77.90	79.71	83.19	86.51
9	91.03	93.83	96.56	99.18	101.7	104.2	106.6	111.3	115.7
10	121.9	125.6	129.3	132.8	136.2	139.5	142.7	149.0	154.9
12	192.5	198.6	204.4	209.9	215.3	220.6	225.7	235.6	145.0

AN INTERNATIONAL EXPOSITION of safety devices and industrial hygiene was opened at the American Museum of Natural History in New York City on Jan. 29 and is to continue for two weeks. The exposition has been organized by the American Institute of Social Service, of which Dr. Josiah Strong is President and Mr. Wm. H. Tolman, 287 Fourth Ave., N. Y. City, is Director. The aim is to call general public attention to the crying need for better protection to the lives and limbs of the workers in American industries.

The exposition was formally opened by a dinner at the Waldorf-Astoria on the evening of Jan. 28, at which Gov. Hughes, of New York, was the guest of honor and chief speaker, and a letter was read from President Roosevelt expressing sympathy with and approval of the movement.

According to the census, 57,513 persons in the United States suffered violent deaths in 1900. Where we have exact figures for comparison they show more than twice as many accidents in this country, relatively, as in Europe.

Such statistics as are available indicate that the total number injured in industrial occupations annually in the United States approximates half a million persons alone. In the railway service alone, 67,000 employees suffered accident in 1904, the last year for which full statistics are available. This was one out of every 19 employees in service.

The exposition is to continue until Feb. 12. Admission is free and it is open to the public day and evening and on Sundays.

MR. WM. J. OLIVER, whose bid for the Panama Canal contract is now pending, has secured as a financial associate Mr. Frederick C. Stevens, who has just been appointed by Gov. Hughes, Superintendent of Public Works of the State of New York, in which office he will have large responsibility in connection with the construction of the New York barge canal. Mr. Stevens is a resident of Attica, N. Y., but has large business interests in Washington, D. C., where he is President of the Commercial National Bank. Mr. Stevens' connection with the Panama contract will be a financial one merely, and Mr. Oliver is to secure other contractors to join with him in the conduct of the work on the Isthmus.

THE TEHUANTEPEC NATIONAL RAILROAD WAS opened formally on Wednesday, Jan. 23. The road is

190 miles long. It connects Coatzacoalcos, on the Gulf of Mexico, with Salina Cruz, on the Pacific Coast, points 125 miles apart across the Isthmus of Tehuantepec. An inaugural trip over the line was made on the day of opening by President Diaz and a large governmental and diplomatic delegation. The distance between San Francisco and New York via Tehuantepec is about 1,250 miles shorter than the distance via Panama between the same ports. The railroad was built by S. Pearson & Son, of London, England, for European interests, with the active aid of the Government of Mexico.

A PREMATURE EXPLOSION OF DYNAMITE at Pearisburg, Va., Jan. 26, killed nine members of a construction gang, employed on the Tidewater R. R. The men were eating their dinner in the works of P. J. Miller, and the dynamite had been placed in front of an open fire to thaw it out.

AN EXPLOSION in the main entry of the Colorado Fuel & Iron Co.'s coal mine at Primero, Colo., Jan. 23, killed 24 men, according to press reports. The accident is supposed to have been caused by a "windy shot." The explosion wrecked the air system and blocked the entrance to the mine.

AN EXPLOSION OF FIRE DAMP in the Pennsylvania Co.'s mine at Lorentz, W. Va., killed twelve miners, Jan. 26. The explosion occurred just as the day force was leaving the mine. The bodies were found about 100 ft. from the foot of the shaft and the men had apparently been overcome by gas, as the bodies were not burned.

A MINE EXPLOSION occurred at Lievin, Pas de Calais, France, Jan. 28. According to reports the bodies of three engineers have been removed and 64 miners are unaccounted for. This mine is located in the Courrieres district, near the mine where the Courrieres disaster occurred last spring. The accident is said to have been due to fire damp, and it is supposed was caused by the engineers experimenting to see if conditions were favorable for carrying on experiments with it. The Minister of Labor had lately appointed engineers to carry on a series of experiments along this line.

A FIRE DAMP EXPLOSION in the Bildstock shaft of the Prussian Government's Reden coal mine at St. Johann-on-Saar, opposite Saarbruecken, Rhenish Prussia, Jan. 28, killed some 200 miners and badly injured others, according to press dispatches. Some 600 men were working in the mine at the time of the explosion, but only about half of them were in the wrecked galleries. The scene of the explosion is 2,100 ft. below the surface and 6,000 ft. from the entrance of the shaft. The bodies of dead horses and debris, which blocked the galleries, retarded the rescue work, and fire finally drove off the rescuing parties before the work was completed. It is stated that the mine had long been considered unsafe.

A DUST EXPLOSION in the White Oak Fuel Co.'s Stuart mine, located near Fayetteville, W. Va., Jan. 29, entombed some 80 miners. It is expected that all these men are dead, as the air system was badly damaged and several hours passed before the fans could be operated. Rescue work was started as soon as the wrecked shaft house could be repaired, but up to the time of going to press none of the entombed men had been found.

A FIRE in the plant of the Phelps Publishing Co., at Springfield, Mass., Jan. 28, destroyed property to the estimated value of $500,000. The burned buildings consisted of one original frame structure in which the fire started and several additions of slow-burning mill buildings, the whole plant being equipped with automatic sprinklers. A watchman discovered a small fire in the basement of the frame building early in the evening, but extinguished it unaided. It is thought that he may have turned off the sprinklers at this time, thus accounting for their non-effectiveness at the later fire. The water pressure in the city mains was entirely inadequate and several engines had to be sent back to their houses on account of lack of water. The loss is mainly in presses and other printing machinery.

FIRE started by an explosion in the paint shop destroyed an entire section of the Baldwin Locomotive Works at Philadelphia, Pa., Jan. 29. The destroyed building was about 157 by 150 ft. and contained the pipe-bending and jacketing departments, brass fitting rooms, paint shops and drafting offices. Although the fire was under control inside of an hour after discovery the presence of so much paint and oil made it extremely inflammable and the loss is estimated at $1,000,000.

A LIMITED TRAIN on the Cleveland, Cincinnati, Chicago & St. Louis R. R. wrecked a street car at Dayton, Ohio, Jan. 26, killed one passenger and injured 16 others, two fatally. The flyer struck the street car fairly in the middle and carried it some 200 ft. before the train could be stopped.

A COLLISION of a locomotive with a caboose on the Mohawk Division of the New York Central & Hudson River R. R., near Albany, N. Y., Jan. 22, killed seven workmen and injured 15 others. The laborers were mostly Italians and were being carried to Albany after the day's work, when the caboose was demolished by the locomotive going in the opposite direction. The caboose was being pushed by a second locomotive, when the accident occurred, according to press reports.

THE BELMONT TUNNEL from 42d St., Manhattan, to Long Island City, according to a recent report of the Chief Engineer of the Bureau of Franchises to the Board of Estimate, requires about 625 ft. yet to be excavated before the north tunnel will be completed, and about 700 ft. between similar points in the south tunnel before that part will be finished. At the rate of progress thus far made it will be at least 60 days before both tunnels meet. The intention of the company building the tunnel is to ask for a franchise to construct a loop at the Queens end of the route and to connect with the present surface trolley line there operated by the New York & Queens County Ry. Co. At the other end of the tunnel the excavation is completed from the foot of 42d St. to the easterly line of Park Ave., including a loop under Park Ave.

SUBWAY LINES ON MANHATTAN ISLAND should run straight north and south, and east and west, according to the Municipal Art Society of New York. This, it is claimed, would greatly simplify the transportation problem, and every precaution should be taken either to utilize now or to safeguard for the future the full capacity of all the north and south avenues for transit purposes. The east and west lines should be placed immediately below the north and south lines, so that both can be accessible by stairway, and the gridiron thus formed should be extended ultimately through and across tunnels and bridges and made to diverge radially in the Bronx district to the north, in the New Jersey district to the west, in the Brooklyn district to the east and south, and in the Staten Island district at the south. Ultimately, but one fare should be charged between lower Manhattan, The Bronx, Brooklyn and New Jersey. Tunnels parallel to the Brooklyn Bridge, between lower Manhattan and Brooklyn, should be begun without delay, and in the meanwhile the Williamsburgh Bridge should be utilized to its full capacity and every effort made to complete the Manhattan Bridge as soon as possible. Continuous transit by moving platform will greatly increase the carrying capacity of the Brooklyn Bridge. The traffic over the Williamsburg and Manhattan bridges should be extended in subway loops across Manhattan, and free transfers provided with the north and south transit lines in this borough. The planning and building of the system should be done by the city with its own capital and then offered in whole or in part to existing railway systems on terms mutually advantageous. The plan thus suggested by the Municipal Art Society of New York practically resolves itself into development under city control with operation by existing companies. By means of pipe galleries installed in the subways, such a policy would tend to bring the gas, electrical and telephone services of the city also under municipal control.

THE TUNNEL CARS to be used in the McAdoo system, which it is expected will be in operation between Hoboken, N. J., and New York City by Sept. 1, 1907, will differ in several respects from those now used in the New York subway. In addition to the entrances at each end of the car there will be entrances midway on the sides, the doors to both end and center entrances being operated by compressed air under control of the guards at the ends of the car. The force applied to the doors for closing them will be just sufficient to bring them shut, so that in case a passenger is entering or leaving the car while the door is closing he will be enabled to stop its progress temporarily. As separate platforms will be provided for loading and unloading, passengers will enter from one side of the car while those within are leaving from the opposite side. Each car will seat at least 50 passengers, and 250 of these cars are being built. Instead of straps for standing passengers, metal posts will be placed from floor to roof at intervals along the sides of the cars in front of the seats. One of the advantages incident to this change is the convenience with which the posts can be grasped at any height by persons of different stature; they are also more stable than the straps which they replace. The floors of the cars will be laid with cement in which will be imbedded quantities of carborundum to prevent passengers from slipping. The reason for selecting a cement floor was largely on account of its high sanitary efficiency, such a floor being readily washed clean. It is estimated the running time from the Hoboken station to 33d Street and Sixth Avenue, New York City, will be 19 minutes, and from Newark to 33d Street, 29 minutes.

ELECTRIC EQUIPMENT OF THE SUBURBAN LINES of the Delaware, Lackawanna & Western Ry. at Jersey City is contemplated as an improvement of the near future. The suburban sections of the road from Jersey City to Montclair and Morristown are to be equipped for electric operation after the Morton St. and Cortlandt St. tunnels under the Hudson River between New York and Jersey City and the new Bergen Hill tunnel are completed. Before the improvement can be begun, however, a considerable amount of grade-crossing elimination must be done on the lines affected.

A 150,000-HP. PLANT, the largest power-house in the world, will be that of the Brooklyn Rapid Transit Co., soon to be built at Kent and Division Aves. in the Williamsburgh district of Brooklyn, N. Y. The structure will be ten stories high and will cost about $5,500,000. The station now in operation at this point contains four turbines from which about 50,000 HP. is obtained. Four Westinghouse turbines, each of 15,000 HP., the largest thus far constructed, are being built for the new part of the station. The completed plant will provide 30,000 HP. more than is now required to operate the entire Brooklyn rapid transit system during the heaviest rush hour. Other improvements planned by the Brooklyn Rapid Transit Co. include the laying of at least one track and in some cases two additional tracks on the present elevated structures. This will enable the company to provide elevated express service to nearly every important part of Brooklyn and the outlying districts, and is said to be contingent upon the construction of the elevated-car loop connecting the Brooklyn and Williamsburgh bridges. According to the plans which have been prepared, the Fulton St. and Brighton Beach lines are to be four-tracked from the Brooklyn Bridge to Coney Island, the Fifth Ave. elevated line is to be four-tracked as far as 36th St., and an additional track is to be laid on the Broadway elevated line from the Williamsburgh Bridge to East New York. The building of these additional tracks will, it is stated, require an expenditure of from $6,000,000 to $8,000,000.

THE PURCHASING OF GOVERNMENT SUPPLIES is to be put under one bureau, according to legislation which is expected to pass Congress this session. The need of centralizing the buying of the large amount of goods used by the government has long been apparent. Under the present system, where each branch of the executive offices has its own purchasing office, acting independently and under separate contract with the selling firm, not only are variable prices paid for the same article but, on account of the added clerical work due to the multiplied number of orders, firms demand a higher price for their goods. It is understood, however, that special apparatus, such as scientific instruments and constructing machinery for the Reclamation Service work, will continue to be bought under the present individual department system.

THE SANITARY PROTECTION OF THE WATER supply of Sydney, N. S. W., in connection with the construction of the Cataract Dam (see Eng. News, Dec. 6, 1906) is described as follows, in a pamphlet recently issued on the occasion of a visit to the dam by engineering and architectural associations on the invitation of Hon. C. A. Lee, Minister for Public Works:

> The whole of the people engaged on the works, together with the tradespeople and others connected therewith, reside on a specially selected area, where every possible precaution has been taken to prevent any contamination of the Sydney water supply. The sanitary arrangements are on the dry-earth pan system. The contents of the pans are buried away from the catchment area, the pans being carefully washed, steamed, and treated before being returned. All soakage and drainage from the township is intercepted and caused to flow through sand filter beds, the effluent being periodically tested.
>
> A duly qualified medical practitioner has been constantly employed on the works, whose duties include a close supervision of all sanitary matters. The result has been most satisfactory and the health of the residents excellent. The sale of intoxicants is not permitted in the township.

Mr. L. A. B. Wade, M. Inst. C. E., Chief Engineer for Rivers, Water Supply and Drainage, is responsible for the design and general supervision. The Supervising Engineer is Mr. E. M. de Burgh, M. Inst. C. E., Mr. J. Symonds acting as Resident Engineer.

THE NEW JERSEY POTABLE WATER COMMISSION, appointed a year or so ago to report on questions pertaining to public water supplies in the State, has reported in favor of the establishment of a permanent commission to have jurisdiction over all public water supplies drawn from surface sources, and also to have other supervisory powers named below. In speaking of the proposed water storage on the upper Passaic, the Commission expresses itself in favor of the dam and reservoir at Little Falls, as recommended by the State Geological Survey, rather than the dam at Mountain View, as recommended by the special Passaic Flood Prevention Commission; but the Potable Water Commission adds that in view of the interests and technical details involved, the subject deserves further study, and it advises that the two plans

be referred to the permanent State water commission, in case one is appointed. Other recommendations made by the Commission are as follows:

The appointment of a permanent State water supply commission, which shall have power to pass upon all new plans for public water supplies when these shall affect surface waters, and to approve all future contracts for surface water supplies entered into by municipalities.

A restriction of the right of any municipality or any water company to acquire, take or condemn lands or water rights for any new or additional supplies from surface sources, and to make new or extend old contracts for such supplies until it has secured the consent of the commission to its plans.

Communities and persons affected by the proposed plans should be given an opportunity to be heard and their objections weighed.

Provision should be made for equitable compensation for all damages resulting from the carrying out of such plans.

The decision of the commission should be subject to review by the courts.

The commission should have power to subpoena witnesses and documents, require testimony, employ the necessary assistants, and require annual reports from all municipal water boards and private water companies of all matters pertinent to a proper supervision of the State's potable waters.

For all water hereafter diverted in excess of the amount at present rightfully and legally diverted by existing municipal water boards or water companies payment should be made at a fair rate to the State. Companies hereafter established should be permitted to divert without payment a daily amount equal to 100 gals. per capita according to the population of the municipality supplied at the last preceding census. On the basis of the past increase in the consumption of water, receipts from these sources in the course of a few years would amount to many thousand of dollars annually, even at a low charge. If the courts should ultimately decide that the State had the right to require payment for all water hereafter diverted, the wisdom of exacting such payment would then be a matter for the legislature to determine.

THE GREAT TELEPHONE GROWTH in the United States during 1906 is indicated by the following figures which relate only to the Bell telephone companies: On Dec. 31 last there were 7,107,835 instruments in use, 1,436,236 miles of toll line, 2,385,742 miles of underground wire, 11,373 miles of submarine wire, and an aggregate of 6,080,282 miles of wire devoted to telephone service. The stations number 2,715,367, and the employees 90,000. Within six years there has therefore been an increase of 349% in the total wire mileage, an increase of 239% in the number of stations, and an increase of 171% in the number of employees.

PERSONALS.

Mr. L. S. Streng has been appointed Chief Engineer of the Kentucky Electric Co., of Louisville, Ky.

Mr. Charles E. Ingersoll, President of the Midland Valley R. R., has been elected a director of the Pennsylvania R. R., to succeed the late A. J. Cassatt.

Mr. J. C. Nelson has been appointed Engineer of Maintenance of Way of the Seaboard Air Line Ry., and not Chief Engineer, as stated in our issue of Jan. 17.

Mr. C. M. Hunt has been appointed Superintendent of the maintenance and transportation department of the Pacific & Idaho Northern R. R., at Weiser, Idaho.

Mr. W. T. Omwake has been elected President of the Waynesboro Water Co., of Waynesboro, Pa. The other officers are: Treasurer, Mr. F. Forthman; Secretary, Mr. E. Eldin, and Superintendent, Mr. D. H. Hoover.

Mr. Frank L. Getman, Engineer of the Ithaca (N. Y.) Water-Works, has been appointed Deputy State Engineer of New York. He will be in charge of the good roads work, and will receive a salary of $4,000 per year.

Mr. O. Le Neve Foster, member of the firm of Vickery, Foster & Collins, Consulting and Contracting Engineers, 422-23 Empire Bldg., Denver, Colo., was married Jan. 17, at Omaha, Neb., to Miss Mabel Alice Pugh, of Boulder, Colo.

Mr. W. R. Armstrong, Assistant Engineer of the Oregon Short Line R. R., in charge of construction of the Yellowstone Park R. R., has been placed in charge of the construction of a low-grade freight line between Huntington, Ore., and Lewiston, Idaho. His headquarters are at Huntington, Ore.

Mr. C. L. Mayne has been appointed Superintendent of Montreal Terminals of the Grand Trunk Ry., to succeed Mr. J. L. Gogerty, resigned. Mr. H. F. Coyle has been appointed Assistant Superintendent of the First, Second and Third Districts, and Mr. L. G. Coleman, Assistant Superintendent of the Fifth, Sixth and Seventh Districts.

Mr. J. A. Joeger has been appointed Chief Engineer of the Santa Fe, Prescott & Phoenix Ry., with offices at Prescott, Ariz. He succeeds Mr. W. A. Drake, who has become Vice-President and Assistant General Manager. Mr. S. W. Higley, Road Master, has been appointed Superintendent of Track, and Mr. George Tisdale, General Foreman of Bridges, Buildings and Water Service, has been made Superintendent of Bridges, Buildings and Water Service.

Prof. J. F. Klein, Professor of Mechanical Engineering at Lehigh University, was tendered a reception by President Drinker and the Lehigh Mechanical Engineering Society Jan. 22, in celebration of the twenty-fifth anniversary of his connection with the college. He was presented with a life membership to the American Society of Mechanical Engineers by the engineering society of the University, and a silver loving cup and a gold watch by the graduates of the mechanical course.

Mr. Theodore P. Shonts, Chairman of the Isthmian Canal Commission, handed his resignation to President Roosevelt Jan. 22, and it was accepted, to take effect Mar. 4. At that time he will assume the active duties of President of the Interborough-Metropolitan Co. of New York City (subway, elevated and surface lines), to which position he was elected Jan. 23. It is stated that he will receive a salary of $50,000 per year in his new position, as against $30,000 as Chairman of the Commission.

Dr. Charles D. Walcott, Director of the U. S. Geological Survey, has been elected Secretary of the Smithsonian Institute, at a salary of $7,000 per year. He was born at New York Mills, N. Y., Mar. 31, 1850, and was educated in the public schools of Utica, N. Y. From 1876 to 1879 he was an assistant in the New York State Survey, when he became Assistant Geologist of the U. S. Geological Survey. Later he became Paleontologist in charge of invertebrate paleontology, then Geologist in general charge of geology and paleontology. He has been Director of the Geological Survey since 1894, and Secretary of the Carnegie Institution since 1902. From Jan. 1897, to July, 1898, he was Acting Assistant Secretary of the Smithsonian Institution. Dr. Walcott is the author of many articles on paleontology and geology, among them being: "Paleontology of the Eureka District," "The Cambrian Faunas of North America," etc.

Obituary.

LeRoy B. Faymonville, Manager of the Hermosillo Electric Plant, died at Hermosillo, Mexico, Jan. 17 of typhoid fever, aged 23 years. He was a graduate of the Massachusetts Institute of Technology.

Andrew G. Blair, formerly Minister of Railways and Canals of Canada, died at Fredericton, N. B., Jan. 25, of heart disease, aged 63 years. He was born at Fredericton and was educated at the collegiate school of that place. He was admitted to the bar in 1866, and in 1878 was elected to the Assembly. From 1883 to 1896 he was Premier of the Province of New Brunswick, when he became Minister of Railways. He resigned in 1904 and retired to private life.

ENGINEERING SOCIETIES.

COMING MEETINGS.

THE NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 4-9. National Convention at St. Louis, Mo. Secy., Theo. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 12-13. Annual meeting at Hartford, Conn. Secy. J. Frederick Jackson, New Haven, Conn.

NEW ENGLAND GAS ASSOCIATION.
Feb. 21. Annual Meeting at Boston, Mass. Secy., N. W. Gifford, East Boston, Mass.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 19-21. Annual Meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

APPALACHIAN ENGINEERING ASSOCIATION.—The annual meeting will be held at Charleston, W. Va., Feb. 2, when the reports of committees, tellers of election and several papers will be read. Headquarters will be at the Kanawha Hotel.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—The annual meetnng of the society was held Jan. 23, in the new Engineering Building. The officers for the ensuing year are: President, Mr. George S. Rice; First Vice-President, Mr. Robert Ridgway; Second Vice-President, Mr. Robert R. Crowell; Secretary, Mr. Clarence D. Pollock; Treasurer, Mr. Arthur S. Tuttle.

TECHNICAL SOCIETY OF THE PACIFIC COAST.—The annual meeting was held at San Francisco, Cal., Jan. 18, when the following officers were elected: President, Mr. Franklin Riffle; Vice-President, Mr. H. D. Connick; Secretary, Mr. Otto von Geldern; Treasurer, Mr. E. T. Schild; Directors, Messrs. Hermann Barth, Edward F. Haas, Hermann Kower, Carl Uhlig and Charles B. Wing.

THE ENGINEERS' CLUB OF PHILADELPHIA.—The twenty-eighth annual meeting was held Jan. 19. The officers elected for the year 1907 are as follows: President, Mr. Henry H. Quimby; Vice-President, Mr. W. P. Dallett; Secretary, Mr. Walter Loring Webb; Treasurer, Mr. George T. Gwilliam; Directors, Messrs. J. W. Ledoux, John T. Loomis and Emile G. Perrot. The next meeting of the club will be held Feb. 2, when Mr. F. E. Wynne will present a paper on "Single-Phase Railways."

WOOD PRESERVERS' ASSOCIATION.—The annual meeting was held at Memphis, Tenn., Jan. 15-17. The officers elected for the ensuing year are as follows: President, Mr. C. W. Lowry, Shirley, Ind., General Manager of the Columbia Creosoting Co.; First Vice-President, Mr. David Allerton, Wyeth, Ore., Superintendent of the Oregon R. R. and Navigation Co.'s Wood Preserving Works; Second Vice-President, Mr. W. Buehler, Minneapolis, Minn., Consulting Engineer to the Kettle River Quarries Co.; Third Vice-President, Mr. Valentine, New York City, Eppinger & Russell Creosoting Co.; Secretary and Treasurer, Mr. C. W. Berry, Laramie, Wyo., Superintendent of the Union Pacific Railroad Wood Preserving Works.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The twenty-third annual meeting of the society will be held at Hartford, Conn., Feb. 12-13. Meetings will be held in the Knights of Pythias Hall, and Tuesday evening an informal dinner will be given at the Hartford Club. Mr. Lewis M. Haupt, Consulting Engineer, Philadelphia, Pa., will deliver an address on "Epochs of Transportation," while among the papers to be read are the following: "Completion and Operation of the New Haven Water Co.'s Filtration Plant," Chas. A. Ferry; "Transverse Contours for Roadway Pavements," H. H. Gladding; "Telephone Subway Construction," Edward H. Everit; "Methods of Laying Submerged Water and Outfall Sewer Pipe," F. S. Wardwell. The election of officers for the ensuing year will occur at this meeting.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.—The twenty-first annual convention will be held at St. Louis, Mo., Feb. 4-9. Hotel headquarters will be at the Planters Hotel, while the meetings will be held in the Planters Convention Hall. As in former years, the week will be divided between the National Association and its affiliated bodies, the American Ceramic Society holding sessions Monday and Tuesday, with a final session Wednesday morning; while the National Paving Brick Manufacturers' Association will meet Tuesday morning. The sessions of the National Brick Manufacturers' Association will begin Wednesday afternoon, but the following sessions will be held in the forenoons of Thursday and Friday. This will leave the afternoons open for inspection trips and sight-seeing. Thursday evening a banquet will be given in the banquet hall of the Planters Hotel under the auspices of the Clayworkers of St. Louis. Among the papers to be read are: "The Importance of Trade Schools for the American Boy," Dr. S. C. Dickey; "Life of Brickwork," Mr. Charles I. Schneider; "Strength of Brick and Brick Piers," Lieut. J. A. Howard; "Permanent Improvement of Public Highways," Mr. E. L. Powers; "Mechanical Versus Hand Work in the Brick Yard," Mr. W. P. Alsip; "Burning Brick With Producer Gas," Mr. C. A. Guignard. Besides some 15 papers there is a list of eleven questions which will be discussed topically.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 213th meeting of this society was held Friday evening, Jan. 25, 1907, in the Auditorium of the Engineers' Building, 29 West 39th St., New York City. Unusual interest centered in this meeting by reason of its being the first one held by the electrical engineers in the new building and on account of the prominence both of the authors of the paper presented and of those who were listed for discussions on the paper. About 1,200 were in attendance. The paper was entitled, "On the Substitution of the Electric Motor for the Steam Locomotive," and was written by Mr. L. B. Stillwell and Mr. H. St. Clair Putnam, consulting electrical engineers of New York City.

The important features of the paper were: The presentation of certain facts established by experience in the operation of elevated, subway and interurban lines by electricity; a discussion of the comparative cost of operation by steam and electricity applied to railways in operation, and including both passenger and freight service; the importance of standardizing electric railway practice; and the question of a standard frequency of 15 instead of 25 alternations in the operation of railways by alternating current. In presenting the paper, Mr. Stillwell emphasized the importance of standardizing electric railway equipment, and he requested a full discussion of the question of frequency. These matters and others relating to the paper were as fully discussed by the speakers who followed as the 10 minutes allowed each of them would permit. It seemed to be the general opinion of all that it was merely a question of time before the electric motor would supersede the steam locomotive on practically all of the railway lines.

Regarding standardization, the important point brought out was the advisability of following steam car practice in this direction, so that it would be possible to change cars from one road to another; this would require a standardization of systems of operation rather than a standardization of details of construction. The most desirable frequency for alternating-current railway operation, according to the majority of the speakers, is 15 cycles per second. Heretofore, 25 cycles has been the customary frequency in American practice. Among those who discussed the paper were Messrs. Sprague, Lamme, Potter, Arnold, Armstrong, Storer, Whitehead and McClellan.